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Setting the Strategy of Insurance Firms using Economic Capital: Concepts and Tools to Manage Risk-Adjusted Performance

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Chapter 1

Context, motivation and summary of original contents

1.1 Context and motivation of this thesis

An "operational" thesis focused on insurers' performance. Insurance should be profitable, just like any other business. However, the insurance business consists in covering risks for policyholders, in exchange of premiums which are paid in advance and can be invested in financial markets. Therefore, insurers must be safe, i.e. actively manage their own risk. In order to do so, they must hold some capital, which can be used in order to cover potential losses.

Depending on the standpoint of who deals with insurers, as recalled by Bailleul et at. in [3], there are two potential extremes that may affect insurance:

- "*L'angelisme*", according to which the *ordre economique* (i.e. shareholders remuneration) gets ignored in the name of the *ordre social* (i.e. policyholders protection), thus leading to an excessively capitalized business which potentially is unsustainable in the medium/long term;
- "*La barbarie*", in which the *ordre social* gets ignored in the name of the *ordre economique*, thus potentially leading to high returns but insufficient capital to protect policyholders.

The responsibility of those who set the strategy of insurance companies is to find the right balance between such two extremes. In other words, Board of

Directors and Top Management should use concepts and tools aimed at measuring and improving (i.e. "manage") the performance of the firm, intended as finding the right trade-off between risk and return.

To the importance of setting clear targets based on which the *strategy* of a company should be defined, Borch dedicated his paper on "Management and objectives in insurance companies" [5]; he thought that "many studies in the theory of risk have lacked a *clear purpose*" and that "actuaries have estimated ruin probabilities and approximated claims distributions, without being very articulate as to how their results could be used in the decisions-making process of an insurance company", although "the responsibility for this does not fall entirely on actuaries".

Top management of insurance companies has "not always been very articulate when it comes to spelling out the objectives of the company, and specifying the kind of information which is required to make the best decisions in the light of these objectives". However, an important contribution toward addressing this shortfall came from the operational approach towards research and risk theory proposed by de Finetti [16], i.e. maximising the expected discount sum of the dividend payments which the company will make over its life time[1].

The current regulatory and market context makes it necessary for insurers and actuarial science to further progress on the path indicated by de Finetti.

New standards aimed at ensuring a solvent and safe insurance industry have been set up. Important investments have been made by insurance firms in the past ten years in order to enhance the way they identify, measure, report and monitor risks (i.e. to set up and improve their "risk management framework"). Such important investments in firms' IT systems, data quality, and methodologies to measure/aggregate Risk-Adjusted Capital came alongside regulatory discussions around new risk-based and market consistent regulatory systems (already in place in Europe, known as "Solvency II" [24], and more broadly discussed in the context of the Insurance Core Principles review and the new International Capital Standards).

[1]A complete literature review on how probabilistic models should be consistenly used to inform decision making is provided by De Felice and Moriconi in [15]

However, these led insurance business to become more expensive and volatile. Such investments made insurance a more expensive (and regulated) business than it used to be. In addition, market consistency increased firm's balance sheet volatility, depending on market conditions, thus reducing the predictability of profitability, dividends and, ultimately, shareholders' returns.

Therefore, insurers have been developing solutions in order to manage risk and capital, using the concept of economic capital. Measuring risk through economic capital has become the way to directly link a firm's specific risk strategy to its capital strategy, using the concept of risk appetite [45] in order to manage risk and stabilize profitability. Firms developed (sometimes very advanced) methodologies in order to aggregate risks, assess their forward-looking solvency position, allocate economic capital to single business units and measure Risk-Adjusted Performance (RAP).

Actuarial research, so far, has not provided a holistic, technically sound framework for such advances. Fostering an insurance-specific research path on economic capital and Risk-Adjusted strategy shall be an important challenge for actuarial science in the coming years. The ambition of this thesis is to contribute to a new research field aimed at setting a *risk-based corporate finance* (as described by De Felice and Moriconi in [15]) and define the strategy of insurance firms using concept and tools to manage economic capital and RAP: a research path aimed at fostering the role actuarial science in serving the interests of policyholders, shareholders, insurance industry and, ultimately, society.

1.2 Structure of the thesis and summary of original contents

The research path underlying this thesis, agreed with the Tutor (Prof. Massimo De Felice), aims at contributing to a new *risk-based corporate finance* for insurance. We start by considering some of the key "practical" issues the insurance industry is dealing with at a European and international level; then, we apply concepts and tools provided by actuarial research to achieve relevant findings/ solutions, whose results are shown in fictious experimental cases (given the wide scope of the thesis, we had no ambition to treat in an exhaustive fashion all the problems that are presented; therefore, symplifications are sometimes used and highlighted in "remark" boxes, providing a view on solutions and relevant bibliographical references).

The thesis is structured into five chapters. All of them (apart from the first one) provide some innovative findings or ideas, which are assessed in specific case studies (in chapters 3 and 4) and described on a formal basis, as summarized below.

Chapter 1 introduces the topic of the research, outlining context, approach and structure of the thesis.

Chapter 2 describes the risk-adjusted performance framework which the thesis is based on. In particular, this chapter describes:

- the four-steps economic capital revolution experienced in the banking and insurance industries (section 2.1);
- why performance should be risk-adjusted and the key notation of a risk-adjusted framework, also showing an original relation among Economic Internal Rate of Return (EIRR), Return on Risk-Adjusted Capital (RoRAC) and Risk-Adjusted Return on Capital (RARoC) (section 2.2);
- examples of profitability and risk measures used in the insurance industry (sections 2.3 and 2.4, respectively);
- the formal definition of Required Economic Capital and the most advanced techniques to measure and aggregate it (in particular, describing the nested stochastic problem and the Monte Carlo with proxy functions solutions which have been recently tested/implemented), as well as to allocate it to single business units (in particular, describing a Continuous Marginal Contribution approach, able to consistently identify a firm-specific "critical scenario") (section 2.5);
- how RAP measures can be used to combine profitability, risk and capital together in a unique holistic view of the firm (section 2.6).

In Chapter 3 we discuss how moving from a traditional to a risk-based profitability model leads to more volatile dividends. This chapter starts from the "traditional" approach suggested by *Dacorogna et Al.* in [11] and evolves it in a market-consistent and risk-based framework. In order to do so, we specify a model to define the dividend policy of a Non-Life company, according to the following 3 steps:

1. define a traditional approach to project profitability and dividends (section 3.1);
2. extend the approach to make it market consistent and risk-adjusted (section 3.2);
3. run the model and analyze results (section 3.3).

The results of the model are followed by a few considerations on the recent debate around market-consistent valuations (section 3.4).

Chapter 4 is the hearth of the thesis, and shows how an Economic Capital model can be used in strategic planning to define an optimal risk-based strategy to steer a composite insurance group. This sets the ground for a new way firms may set up their strategy and plan/ monitor their business. In this chapter we:

- recap the key ingredients necessary to perform a business planning exercise (section 4.1);
- define an original Economic Capital model (some of whose preliminary results were already presented by the Author in [51] and [41]) for a fictious composite insurance group, in order to explore how management intiatives (e.g. capital allocation driven by diversification benefit, change in Strategic Asset Allocation or in the Underwriting strategy) can be assessed and selected in a risk-adjusted framework, showing how a strategy based on Return on Economic Capital (RoEC) leads to very different decisions compared to traditional strategies based on Return on Equity (RoE) (section 4.2);
- discuss how firms set their capital management plans and dividends policies coherently with their risk appetite and forward-looking solvency assessment (section 4.3);

- suggest an innovative 4-steps approach aimed adjusting product pricing in Non-life business for risk and allocated capital (section 4.4).

Chapter 5 outlines the conclusions of the study addressing three topics. Such topics are deemed by the Candidate to be key for the (immediate) future of actuarial practice and research in an evolved insurance industry, and are:

- the way insurance firms operate, so that risk is properly taken into account and decision making takes economic capital into account (section 5.1);
- the way insurance firms are valued, in terms of new metrics able to help investors to make more informed decision when trading insurers (section 5.2);
- the essence of the role of actuaries, which can evolve from pure technical specialists to professionals equipped with the right skills in order to steer, influence or control the strategy of a firm (section 5.3).

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[a]Including at least Taras Androschuck, Matteo Coppola, Gerardo Di Filippo, Jan-Hendrik Erasmus, Giovanni Fassio, Marco Giunta, David Honour, Francesco Merlin, Anastasios Panagiotou, Marco Pirra, Gianluca Sanmartino, Erik Stattin and Anna Vita.

Chapter 2

Economic Capital and Profitability in a Risk-Adjusted framework

This chapter aims at achieving four objectives:

1. illustrate the meaning and historical references about Economic Capital in the financial services industry;
2. explain why adjusting profitability for risk is importat in order to measure performance of firms;
3. describe the latest advances in the insurance industry in terms of economic capital measurement and allocation;
4. discuss how Risk-Adjusted Performance Measures can be used to combine profitability, risk and capital together in a unique holistic view of the firm.

In order to achieve these aims, the next sections discuss:

- a brief historical background of economic capital in the banking and insurance industries (section 2.1);
- the key notation of a risk-adjusted framework (section 2.2);
- examples of profitability and risk measures used for insurance (sections 2.3 and 2.4, respectively);

- approaches and techniques to measure economic capital and allocate it to single business units (section 2.5);
- which measures can be used in order to consider profitability, risk and capital in a unique holistic view (section 2.6).

2.1 An Economic Capital "revolution"

Economic Capital became in the past few years the key metric in the financial services industry, linking the economic (cash-flow based) view with the balance sheet and solvency (risk based) view of financial insitutions such as banks and insurers. Albeit this has implied a revolution in the way the market looks at such firms, the path towards embedding economic capital in the way firms are managed has not been completed yet. Firms who will be able to complete this evolution on a both timely and sound basis will end up having a comparative advantage with respect to peers. In order to manage such revolution and get the most value out of it, a number of tools have been provided by academic and scientific research in the actuarial and financial sciences, as further described in this chapter.

Looking at recent history of insurance industry, four different pushes can be identified in the way firms evolved towards embedding economic capital in the way they manage their business. A fifth push is next to come, and is expected to absorb much of the capabilities and focus of financial insitutions in the next few years:

1. the "*banking push*": The revolution first started in the banking industry with the first examples of economic capital based measures dating back to the '80s[1], and then formalized and embedded in the new regulatory framework of Basel II, published in final form in 2006, which requires banks to conduct an Internal Capital Adequacy Assessment Process (ICAAP)[2] to demonstrate that they have implemented methods and procedures to ensure adequate capital resources, with due attention to all material risk;

[1] An interesting overview on this history is provided by Wilson in [52]

[2] Regulatory references are provided by the European Central Banks in [23]

2. the "*regulatory push*": A proper jump in the european insurance industry was fostered by Solvency II after 2008, which explicitly refers to the Solvency Capital Requirement as

> "the *economic capital* to be held by insurance and reinsurance undertakings in order to ensure that ruin occurs no more often than once in every 200 cases, or alternatively, that those undertakings will still be in a position, with a probability of at least 99.5% to meet their obligations to policy holders and beneficiaries over the following 12 months", as specified by the Directive [24];

   Solvency II is not expected to be left as a voice in the wilderness, as it is perceived to be the first step towards a worldwide revision of the Insurance Core Principles (ICPs) promoted by the IAIS[3].

3. the "*methodology push*": Both academia and insurers invested great efforts in order to design sound methodological solutions and ensure compliance with the new requirements. To make reference to a few important case studies, Aviva implemented the first Group-wide economic capital model consistently with the new Solvency II requirements in 2009 and used it for disclosing the year-end 2009 ICA[4] results to the Regulator; since then, the model (once called the "S2EC model") evolved to the new internal model ("Algo"), which has been approved by the PRA on the 5/12/2015; likewise, Allianz launched in 2008 an internal multi-year Solvency II Umbrella Project to meet Solvency II internal model requirements, and the model was approved by BaFin in november 2015; in Italy, Generali Group started the development of the new Solvency II-compliant internal model in 2013, receiving approval by IVASS in March 2016.

4. the "*IT push*": Huge investments have been made by insurers to upgrade their IT and data systems in order to (i) convert

[3]International Association of Insurance Supervisors

[4]Individual Capital Assessment, a risk-based self assessment of the firm's capital adequacy, which must be communicated to the regulator. The requirement was introduced by the UK Authority (once called FSA, now the PRA) starting from year-end 2004.

to practice the newly designed methodological frameworks and (ii) ensure that the new data quality regulatory requirements would be met. Therefore, each model mentioned in point (3) above proceeded together with huge effort in terms of systems and IT infrastuctured in order to ensure the quality of data used by the models and enable the implementation of the designed methodology.

As discussed, the momentum fostered by each of the four pushes above is not over yet, however the fast movers among firms have gone far in those direction and are now in a refining phase. In other words:

1. on the banking side, the ICAAP exercises have been included in a wider more comprehensive framework which regulators are using to assess each firm, called SREP[5] (see the manual issued by the European Central Bank in [23]), where capital adequacy, risk, governance and profitability inherent in the bank's business model are all accounted for in a unique holistic framework;

2. the Solvency II Directive has now been converted into ordinary law by each of the Member States (albeit the transition from the old regime is yet to be managed) and the IAIS is now focusing on three components of what's been called by BCG the new insurance regulatory wave (see [9]), i.e. ICPs, ComFrame and G-SIIs[6] supervision and resolution;

3. new methodologies have been designed and are now being refined, as reported above;

4. IT systems have been upgraded and are now in production (i.e. they are in the so called "change management phase").

These four pushes enabled a revolution in how firms' risk and capital profile is measured and monitored. The next big push will be on the value generation through economic capital management, involving the embedding of economic capital in the day-by-day management of the business in terms of capital management, business planning and new product design and pricing. These three areas are further discussed in the next chapters. The rest of this chapter

[5]Supervisory Review and Evaluation Process
[6]Global Systemically Important Insurers

aims at providing a sound methodological framework in order to be able to navigate in how Economic Capital can be used to extract value while being equipped with the most advanced concepts and tools used in practice and known to the literature.

2.2 The risk-adjusted strategic framework

The underlying idea of this thesis is that, in order to successfully plan, manage and monitor insurance business, three views are necessary, whose features will be further detailed in the next chapters:

- profitability view: ensures that the firm's business model is such that it is sustainable in the medium long term (i.e. "it makes money"); the highest example of document expressing the strategy of the firm towards this view is the traditional 3-years business plan; the key metric referred to this view is the "net income";
- risk view: enables the firm's risk profile to be constantly monitored and actively managed within shareholders' risk appetite; the highest example where this view is materialized is the Risk Appetite Framework; the key metric referred to this view is the "Required Economic Capital"[7];
- capital view: ensures that the balance sheet structure of the firm is optimal considering the firm's risk profile and shareholders' cost of capital and remuneration targets; the highest example of document expressing the strategy towards this view is the Capital management plan; the key metric referred to this view is the "Available Economic Capital".

Combining these three views toghether enables the design of the Risk Adjusted Performance Measures (RAPMs). Also, the dividends policy of a firm (and thus its ability to remunerate shareholders while being sustainable in the long term) depends on how it performs according to each of these views.

Now, to introduce the concept of RAPMs, let us consider an investor who can invest in a fixed set of d different investment opportunities with

[7]Sometimes also referred to as Risk-Adjusted Capital

Area of application	**Investor**	**Meaning of $L_i, i = 0, ..., d$**
General investment	Asset manager	Return from d asset classes
Performance measurement	Financial institution	P&L from d LoB[8]
Loan/ product pricing	Book manager	P&L from d products

Table 2.1: Areas of application of RAPMs and interpretation of losses

losses represented by the random variables $L_1, ..., L_d$. The alternative interpretations, depending on the area of application, can be as shown in Table 2.1.

The objective of a RAPM is to provide a uniform measure of performance that Management can use to compare economic profitability of businesses with different sources of risk and different capital requirements. This is made by:

- making risky returns directly comparable, i.e. by "normalizing" returns offered by different opportunities for the risks taken, and
- measuring value creation, i.e. by comparing the "normalized" returns against a common cost of capital or hudle rate to assess whether the opportunity is creating or destroying value.

As such, there are a number of properties that are desirable for any effective RAPM. In particular, the measure should be:

- *consistent*: defined and calculated consistently across business lines and products (and across different entities at Group level);
- *economic*: based on economic measures that are sensitive to profits generated and reflect the actual risks involved (i.e. it relates to the actual risks being run - to which shareholders are exposed - and makes an allowance for uncertainty within cashflows);
- *efficient*: can be implemented easily, is based on data which are available, its calculation can be performed quickly, is straightforward to use;
- *auditable*: is transparent and its calculation can be easily replicated in order to gain credibility and perform sensitivity analyses;
- *communicatable*: simple enough for staff to understand and communicate to senior management and to the Regulator;

- *suitable for 'retrospective' applications*: can be used for evaluating the historical performance (e.g. to assess company's results) and can be calculated at the required level of granularity in line with Management responsibility (e.g. at Business Unit level);
- *suitable for 'prospective' applications*: can be used for strategic and business decisions such as business planning, capital allocation and new business pricing.

2.2.1 Why profitability should be risk-adjusted

Until the fostering of portfolio theory in the 1960s, the problem of measuring the performance of portfolio managers had initially been addressed by comparing the total returns of a managed portfolio with that of a random unmanaged portfolio (the "dartboard portfolio"). The latter was then replaced by an unmanaged market portfolio (or, better, capitalization-weighted portfolio consisting of the entire market) and, thereafter, by benchmarks built to reflect more closely the desired characteristics of the portfolio under evaluation (e.g. the risk-appetite, time-horizon of investment etc.)[9]. As such, the common measure of performance usually was the "total return".

The main drawback of "total return" measures is that they ignore the fact that investors can increase expected returns simply by accepting higher level of risk. However, investors do not like risk, and hence they require compensation in the form of a "risk premium" for any uncertainty embedded in investment outcomes. These "risk premia" can be easily observed, measured and, actually, acquired on an open market, and hence, when included in a return measure, they do not reflect any particular skill of the investor, but simply their willingness to undertake more risk. The underlying idea in making the investment performance measure "risk-adjusted" is that after such adjustment is applied the measure should not be sensitive to increased return results achieved by simply increasing exposure to risk.

The following paragraphs provide an overview on two well known risk-adjusted return measures.

Sharpe ratio as the first RAPM. The Sharpe ratio was introduced in [47]. It is given by the ratio between the extra-return (also called risk pre-

[9] Such benchmark approach still today represents the standard market practice in the pensions sector

mium) of the portfolio (or line of business or asset class) above the risk-free rate of return over the standard deviation of the return itself. The ratio can be interpreted as the “reward per unit of risk”, i.e.

$$SR_A = \frac{r_A - r_f}{\sigma_A} \tag{2.1}$$

The main drawback of Sharpe ratio is that it has no units, and hence is not directly comparable with benchmarking returns.

Modigliani’s RAP. Modigliani’s Risk-Adjusted Performance (Modigliani’s RAP) aims at measuring performance of any managed portfolio against a notional unmanageable “market” portfolio. The idea is to use the market opportunity cost of risk to adjust all portfolios and put them on the same level of risk with the market. In this way, all portfolios will have the same risk profile, and will therefore be directly comparable.

Namely, for any portfolio A having total return r_A and standard deviation σ_A, we follow a 2-steps procedure:

- a new portfolio A' is constructed, in which we de-leverage (i.e. sell a share to put in risk-free asset) or leverage (i.e. borrow at risk-free rate to buy a share) by an amount d_A

$$d_A = \frac{\sigma_M}{\sigma_A} - 1 \tag{2.2}$$

  The level of (de-)leveraging is such that the risk of the new portfolio is equal to the market’s, so that $\sigma_A = \sigma_M$;

- Modigliani’s RAP is equal to the total return on the risk-adjusted portfolio

$$RAP_A = r_{A'} = (1 + d_A)\, r_A - d_A r_f$$

  which, by using 2.2 and 2.1, can be rewritten as

$$RAP_A = r_f + (r_A - r_f)\, \frac{\sigma_M}{\sigma_A} \tag{2.3}$$

$$RAP_A = r_f + SR_A \sigma_M \tag{2.4}$$

$$RAP_A = r_A + SR_A\, (\sigma_M - \sigma_A) \tag{2.5}$$

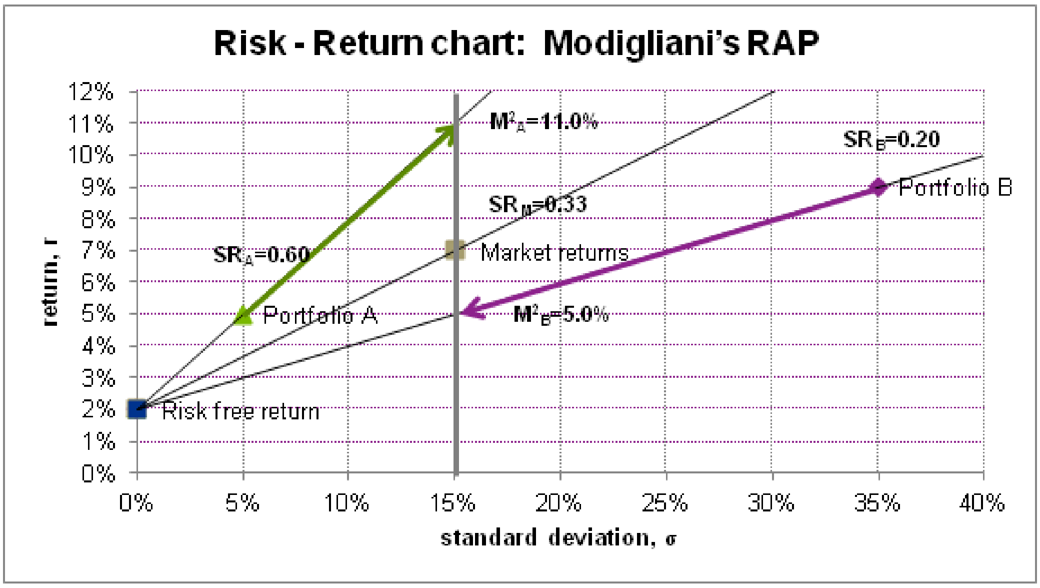

Figure 2.1: Modigliani's RAP (M^2) is directly comparable with market returns

Portfolio i	r_i	σ_i	SR_i	RAP_i
A	5%	5%	0.6	11%
B	9%	35%	0.2	5%
M	7%	15%	0.33	7%

Table 2.2: Sharpe ratio and Modigliani's RAP for two illustrative portfolios

The last formula allows us to obtain graphical interpretation of Modigliani's RAP on the same risk-return chart, used for Sharpe ratio. Indeed, if one draws a vertical line from the point representing market portfolio (see Figure 2.1), the point of intersection of this line with the line that determines Sharpe Ratio for a portfolio will represent Modigliani's RAP of this portfolio.

Unlike the Sharpe ratio, Modigliani's RAP is expressed in percentage or basis points, hence it is directly comparable with market returns.

Let A and B be two portofolios yielding the rate of return of $r_A = 5\%$ and $r_B = 9\%$, where the market index gives $r_M = 7\%$ and the risk free rate is 2%, and with standard deviation $\sigma_A = 5\%$, $\sigma_B = 35\%$ and $\sigma_M = 15\%$.

By applying the 2.1 and the 2.5, we obtain the results shown in Table 2.2.

Looking at total return, at the Sharpe ratio and how they relate to each other, one could conclude that Portfolio A outperforms the market (i.e. although reaching a lower return, the level of risk undertaken is more than proportionally lower), while Portfolio B underperforms the market and Portfolio A.

Using Modigliani's RAP enables to quantify the extent of such performance differences, so we conclude that in a risk-adjusted world portfolio A outperformes the market by 4%, which in turn outperforms B by 2%.

2.2.2 The generic representation of RAPMs

As a number of studies pointed out (such as [25]), Sharpe measures and other measures within a CAPM framework (such as Beta) present calibration issues due to the lack of market data and do not consider the risk and costs associated with default. This led to the design and development of performance measure able to allow for the whole risk inherent to a given portfolio.

According to a research performed by Bank of America [53], the Banking Trust developed the RAROC methodology in the late 1970s and the original intent was to measure the risk of the bank's credit portfolio and the amount of equity capital necessary to limit the bank to a specific probability of loss. By 1995, Bank of America had also developed the capability to allocate capital and calculate risk adjusted performance down to the level of individual products and transactions.

In most cases, RAPMs are defined either as the ratio of the profitability of the business over a measure of the risk undertaken (see 2.6 below), or as the ratio of the risk adjusted profitability over the capital invested (see 2.7). The following formulae represent, respectively, the concept of Return on Risk Adjusted Capital (where the profitability level is compared to the amount of capital invested in the risky asset plus a risk-adjustement) and of Risk Adjusted Return on Capital (i.e. the ratio of profitability "normalized" for the risk taken over the allocated capital); hence, they provide an excellent example of how the three views above, i.e. profitability, risk and capital, can be analyzed jointly.

$$RAPM_1(RoRAC) = \frac{Return}{Capital + Risk\ Adjustment} \tag{2.6}$$

$$RAPM_2(RARoC) = \frac{Return - Risk\ Adjustment}{Capital} \tag{2.7}$$

Remark 2.1 (on the Risk Adjustment in a RoRAC measure) Looking at the two definitions of RAPMs above, one could ask about the nature of the risk adjustment to be applied to capital or return:

- let us consider the available capital of a company: this is a form of non-adjusted capital, which could in theory be very close to zero;
- now, the corresponding risk-adjusted capital (which we call REC in this thesis, or Required Economic Capital) could well be higher than the capital, as it represents the additional amount of capital the company should hold in order to ensure it will be solvent over the next 1-year with an "alpha" level of confidence (this "alpha" represents the risk appetite: the lower the risk appetite, the higher the risk adjustment, and vice-versa);
- of course, if the available capital of a company is higher than its REC, then the risk adjustment is negative (and the company is able to pay dividends, as we will further discuss in chapter 4).

The following sections focus on each of the three item in an insurance context: profitability, risk and capital. First, however, we provide an example of how a “traditional” profitability measure such as the Internal Rate of Return (IRR) can be risk-adjusted.

Example: The Economic Internal Rate of Return. The Internal Rate of Return (IRR) is one the most widely used financial measures to evaluate investments that generate cash flows extended over some interval in time; it can be used to rank several alternative projects for a firm.

The IRR is defined as such a discount rate that results in the net present value of the future cash flows generated by the project to be equal to zero. More formally, if $\bar{X} = \{X_t\}_{t=1,\dots,T}$ are the future cash flows generated by the project, the Internal Rate of Return

$$IRR = i^*$$

is such that the Net Present Value (NPV) at time $t = 0$ of the investment is zero

$$NPV\left(0,\bar{X}\right)=\sum_{t=0}^{T}X_{t}v\left(0,t;i^{*}\right)=0 \tag{2.8}$$

where $v\left(0,t;i^{*}\right)$ is the discount factor.

Two approaches will be considered to risk-adjust the IRR:

- approach 1: Adjust the cash flow $\bar{X}$ to consider an initial capital requirement needed to cover uncertanties of the future cash flows, as a sort of "capital strain" to be set aside at time 0;
- approach 2: Adjust the cash flow $\bar{X}$ to consider the notional cost of capital in the single future cashflows.

We'll illustrate the two approaches using an example.

Say that $\bar{X}$ is such that:

- there is an initial outflow $X_0 = 100$;
- which is followed by 20 positive inflows, all of which are equal to $X_t = 10,\ t = 1, ..., 20$.

Then, we'll have that $IRR\left(\bar{X}\right) = 7.8\%$.

Under Approach 1, let's say that, in order to realise the cash flow in the above example, the firm is required to put aside a risk capital equal to 50 at time zero. This capital is than released over the next 20 years by equal parts of 2.5 at the end of each year. If these capital movements are added to the correspondent original cash flows, the new cash flow profile is than equal to:

$$\widetilde{X_0} = -100 - 50 = -150$$

$$\widetilde{X_t} = +10 + 2.5 = 12.5,\ t = 1, ..., 20$$

which leads to an Economic Internal Rate of Return of $EIRR_1\left(\bar{X}\right) = 5.5\%$.

Under Approach 2, let's assume that the market price for capital resources for the type of projects which is considered above is equal to 4% p.a.; in this case the new adjusted cash flows will be equal to:

$$\widetilde{X_0} = -100 - 50 \cdot 4\% = -102$$

$$\widetilde{X_t} = 10 - (50 - 2.5 \cdot t) \cdot 4\%,\ t = 1, ..., 20$$

which results in an Economic Internal Rate of Return of $EIRR_2\left(\bar{X}\right) = 6\%$.

The results under the two risk-adjustment approaches are different. It should be noted that both approaches rely on some "external" measures of the risk implicitly given in the following three values:

- value of the required capital,
- the capital release time structure, and
- cost of capital rate.

Since the above values are not necessarily inter-consistent, we cannot expect that in general case the two risk-adjusted IRR measures will be equal.

Remark 2.2 (on the Relationship between EIRR, RoRAC and RARoC). It is interesting to notice that special case of the two approaches above are, respectively, the RoRAC (Return on Risk Adjusted Capital) and the RARoC (Risk Adjusted Return on Capital) measures, where $T = 1$.
Considering Approach 1, if the initial out-flow is -$\widetilde{X_0}$ (including a risk adjustement) and the in-flow at $t = 1$ is X_1, then, discounting by linear compounding, we have that

$$-\widetilde{X_0} + \frac{X_1}{(1 + EIRR_1)} = 0$$

$$X_1 - \widetilde{X_0} = \widetilde{X_0} \cdot EIRR_1$$

$$EIRR_1 = \frac{\Delta X}{\widetilde{X_0}} \tag{2.9}$$

which is the ratio of return over invested risk-adjusted capital.
Considering Approach 2, if the initial outflow is -X_0 and X_1 is the risk-adjusted inflow at $t = 1$, then, discounting by linear compounding, we have that

$$-X_0 + \frac{\widetilde{X_1}}{(1 + EIRR_2)} = 0$$

$$\widetilde{X_1} - X_0 = X_0 \cdot EIRR_2$$

$$EIRR_2 = \frac{\Delta \widetilde{X}}{X_0} \tag{2.10}$$

which is the ratio of risk-adjusted return over invested capital.

The following sections focus on each of the three item in an insurance context: profitability, risk and capital.

2.3 Profitability measures in insurance

Many different indicators to assess profitability exist in the insurance market, the reason for such a diversity being related to factors such as type of business considered, regulation in force, historical heritage, purpose for which the assessment is performed.

Given an insurance portfolio, the pace of recognition of profits is one of the key aspects of financial reporting. The speed at which these are recognised varies significantly between different financial reporting bases, albeit the ultimate overall profitability is effectively the same. The most significant aspects determining the pace of recognition are as follows:

- the extent to which acquisition expenses can be deferred;
- whether initial charges are required to be deferred;
- whether the present value of future profits can be recognised at inception.

The speed of recognition on a particular basis also depends on the considered product. In general, bases giving higher importance to protecting policyholders (which is often the case in local GAAP) should use "more prudent" assumptions than those which are more focused on shareholders' value (e.g. MCEV[10]).

In general, some of the key elements of profit reporting under different bases (e.g. how provisions are calculated, how quickly profits are recognized) can be summarised as follows:

- *Local GAAP – cash basis*: Provisions are calculated using prudent assumptions; speed of recognition of profit is low due to the progressive release of prudence, however future profits are recognized at the valuation date;

[10] Market Consistent Embedded Value, calculated using 17 principles published by the CFO forum in June 2008. The reporting system is designed to focus on shareholder interests.

- *IFRS 4 Phase I*: Although provisions should follow in principle a fair value approach (using realistic assumptions), in practice companies usually adjust Solvency I figures (for example, to allow for Deferred Acquisition Costs); speed of recognition of profit is therefore low (as recognition of future profit is deferred); IFRS 4 Phase II is under discussion and is likely to require a single measurement approach that will apply to all insurance contracts, switching towards a market consistent approach;

- *MCEV / EEV*[11]: Provisions are calculated using realistic assumptions; the speed of recognition of profit is high, as the value of future profits is considered at the valuation date; hence, the value of profit recognised in projected years is generally lower, compared to other bases;

- *Solvency II*: Provisions are calculated using realistic assumptions (with some exceptions); speed of recognition of profit is high; value of future profits is considered.

The following paragraphs provide an introduction to three of the most widely used and well known economic profitability measures in the insurance market.

MCEV Operating Profit. Profit arising from a given portfolio can be defined as the positive change in the economic value of that portfolio. MCEV is a good candidate for measuring economic value, as it represents "the present value of shareholders' interests in the earnings distributable from assets allocated to the covered business after sufficient allowance for the aggregate risks in the covered business", as stated by the CFO forum in [8].

Two approaches for calculating MCEV have been proposed and are used in practice, as illustrated in Figure 2.2:

- *Balance Sheet approach*;

- *Earnings approach.*

[11]A consistent basis for European Insurers to prepare their Embedded Value Reports, the "European Embedded Value" follows twelve principles and guidelines that were launched by the CFO forum in May 2004 and were formally adopted at the end of 2005. EEV provides explicit allowance for cost of capital and time value of options and guarantees.

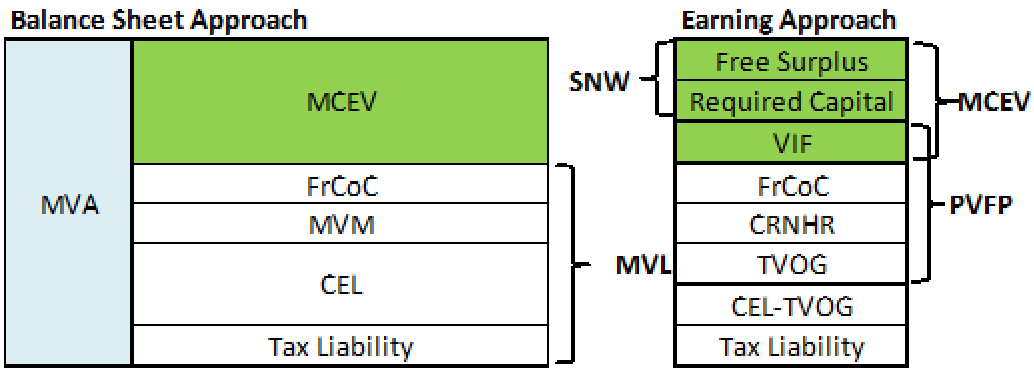

Figure 2.2: The two MCEV approach

Under the *Balance Sheet approach*, MCEV is seen as the difference between the Market Value of Assets (MVA) and the Market Value of Liabilities (MVL). The latter is intended as the sum of Frictional Cost of Capital (FrCoC, reflecting investment and taxation costs on the assets backing required capital), Current Estimate of Liability (CEL, which includes the Time Value of Guarantees, TVoG), Market Value Margin (MVM) and the tax liability.

Under the *Earnings approach*, MCEV is obtained as the sum of Value of In Force (VIF), the Required Capital C_t (under local regulations) and Free Surplus. The VIF is the only part of the Present Value of Future Profits (PVFP) which is included in MCEV: profits associated to FrCoC, to the Cost of Residual Non Hedgeable risks (CRNHR) and to the TVoG are considered part of the MVL. In this (simplified) view, Shareholders' Net Worth (SNW) is the sum of Required Capital and Free Surplus.

Analysing the return on embedded value is a useful exercise at least in order to

- compare actual experience against expectations,
- provide management with the value of new business written in a year, and
- identify any actions to take future advantage of profitable business or limit future losses (e.g. unprofitable contracts that should be re-designed or re-priced, as taught in actuarial exams, like UK's [29]).

The Embedded Value Earning (EVE) generated in the $(t, t+1)$ time horizon is defined as MCEV operating profit minus the return gained on employed capital C_t:

$$EVE_{t,t+1} = OP_{MCEV,(t,t+1)} - r_{t,t+1}C_t \tag{2.11}$$

where MCEV operating profit is given by:

- the unwind of the risk discount rate r (i.e. the return on the opening VIF using the risk discount rate), which represents the profit due to the fact that future cash flows are discounted for one year less;
- minus the expected profit emerging in $(t, t+1)$ from in-force business (expected given assumptions as at t);
- plus the Value of New Business written, which is obtained by discounting future profits expected for new business (i.e. expected revenues less acquisition expenses), using the risk discount rate;
- plus experience variances, i.e. any movement in the VIF experienced in $(t, t+1)$ arising from differences between investment assumptions in t and in $t+1$;
- plus any impact of operating assumptions changes, e.g. in the reserving bases;
- less development costs in $(t, t+1)$;
- plus return on opening SNW expected by shareholders.

In terms of desirable properties, the Embedded Value Earning gives a realistic measure of profit which can be applied consistently to new business and to in-force business. It can therefore be suitably used for new business pricing as well as to consider the impact of potential business decisions. As a measure, it does consider cost of capital required, however the capital considered does not necessarily provide a realistic measure of the risk of the portfolio. Other downsides are the potential misalignment with other accounting bases (reconciling with IFRS is not a trivial exercise, for instance) and the fact that it has historically been designed for life business rather than for non-life business.

Solvency II Operating Profit. Solvency II (S-II) profit is defined as the change in shareholders' Solvency II Basic Own Funds OF (excluding capital movements such as dividends). It provides an estimate of the increase in the value of the business (based on a S-II basis). In terms of properties of this measure, the assessment is similar to MCEV Operating Profit. Note that S-II Profit, although being market-consistent and therefore (in principle) reflecting a realistic view of the firm, is not adjusted according to the level of risk underlying the portfolio, and it doesn't allow for the firm's internal risk appetite.

Free Cash Generation. Free Cash Generation (FCG) is a measure used to present the business plan of an insurance company to investors and to make decisions in terms of dividends policy. Its relevance as a profitability measure is due to at least two basic factors:

1. it is a "pure cash" (after tax) measure, and allows for changes in regulatory capital requirements (therefore its relevance for the dividends policy);

2. it is consistent with the accounting basis, and is calculated in a very similar way as IFRS cash generation.

It can be defined as the Net Profit (after tax, $\Pi_{t,t+1}$) after removing any movement in the Required Capital (C_t) over the considered time horizon (usually one year):

$$FCG_{t,t+1} = \Pi_{t,t+1} - \Delta C_{t,t+1} \tag{2.12}$$

Free Cash Generation is therefore the surplus generated by the insurance business after allowing for the impact of regulatory capital requirements.

Measuring Free Cash Generation is especially relevant for shareholders, since the generation of free surplus plays a key role in determining the dividends policy of the firm. The dividends topic will further be investigated in Chapter 3.

In terms of desirable properties, the calculation of FCG is quite straightforward, transparent and not very time consuming, given that required input data is generically available. Being a "cash" measure, it is easily understandable and acceptable by Regulators and senior management. Among the downsides, however, it is not risk-adjusted (unless regulatory capital is defined as Required Economic Capital, as we shall see in the next section), it's not an economic measure (no allowance is made for cashflows' uncertainty) and is not suitable for prospective purposes (e.g. new business pricing). The risk-adjusted version of FCG is *Sustainable Free Surplus* (FSF), which is defined in section 2.6.

2.4 Risk measures in insurance

Concepts, definitions and tools related to risk measures are covered in detail in [36]. Below we provide a few highlights which will be useful in the rest of this thesis.

Definition of risk measure. A risk measure is any functional (mapping) $\sigma(\cdot)$ that assigns a monetary amount $\sigma(X) \in \mathbb{R}$ to a given probability distribution of a variable X and increases monotonically with the level of risk exposure underlying that probability distribution forecast[12]. The following list provides a few example of most widely known risk measures:

- *Standard deviation*, given by

$$SD_c(X) = c \cdot \sqrt{E(X - E[X])} \tag{2.13}$$

  where the constant c can be expressed in such a way that for some 'representative' X_0 (e.g. a loss distribution of an average firm for the market) we have that

$$P(X_0 \geq E[X_0] + SD_c(X)) \leq \alpha$$

  for some small α (e.g. $\alpha = 0.5\%$);

- *Value at Risk (VaR)*, given by

$$VaR_\alpha(X) = F^{-1}(\alpha) = inf\{x \in \mathbb{R} | F_x(X) \geq \alpha\} \tag{2.14}$$

  i.e. the worst possible outcome (loss) that can occur within a certain level of probability $(1 - \alpha)$. The capital defined as VaR will be suffi-

[12] An exhaustive discussion on risk measures and coherence properties is provided by McNeil et al. in [36], and a synthesis in [39]

cient to cover losses that may occur to the firm with probability$(1-\alpha)$, however it does not make any consideration of loss events beyond the $(1-\alpha)$-quantile of the distribution of outcomes;

- *Conditional Tail Expectation (CTE)*, given by

$$CTE_\alpha(X) = E\left[X | X \geq VaR_\alpha(X)\right] \tag{2.15}$$

  i.e. the expected outcome (loss) beyond the $(1-\alpha)$-quantile;

- *Expected shortfall (ES),* given by

$$ES_\alpha(X) = \frac{1}{1-\alpha}\int_\alpha^1 VaR_u(X)\,du \tag{2.16}$$

  i.e. the expected loss in the $(100 \cdot \alpha)\,\%$ worst cases.

In this thesis we will focus on the risk measure which is proposed by Solvency II to calculate firms' Required Economic Capital in the European Union.

In general, Economic Capital is an internal firm-specific measure of the capital required given company's risk appetite and on-going business strategy. It is calculated as the value of assets in excess of liabilities so that, allowing for (all) the risk factors which the firm is exposed to, claims can be met with a "high degree of certainty". Economic Capital can be interpreted as a monetary measure of risk. Required Economic Capital is defined in the next section.

2.5 Capital measures in insurance

In order to calculate the appropriate performance measure in the form of a rate-of-return, several non-risk-adjusted quantities can be used.

For instance, *assets* are widely used by market analysts in ROA (Return on Assets) measures, and provide an interesting denominator to measure economic efficiency of the business. It is a valid indicator for a management's point of view, although it is of little use for shareholders and to make business decisions (for example because allocating assets to specific lines of business is not always an easy exercise).

Another popular denominator used to assess profitability against is *sales* (e.g. measured as Present Value of New Business Premiums). Using these as a denominator might be preferable, for example, when the standpoint is that of Regulators, if the objective is to assess policy rates offered by an insurer to the market (see [35]).

In the next subsections we will hint at other potential candidates such as

- Equity capital;
- Available Economic Capital (AEC).

Then, we will conclude that if we want to assess the Risk-Adjusted performance of a considered investment/LoB, then a ratio having some risk measure (e.g. allocated economic capital) as the denominator should be used.

2.5.1 Equity capital

Equity is usually a preferable measure when the company's-wide financial performance is concerned from a shareholders' point of view. It can be defined on an accounting basis as the balancing item between the value of assets and the value of liabilities[13]. Although being a widely used denominator for defining the performance of a firm from the shareholders' point of view, its downsides in the RAPM context is that Equity does not allow for risk, and it is not easily allocated across the different components of the business (e.g. products, functions, risk factors etc.). In chapter 4 we also investigate the significant problems which defining the strategy of a firm based an equity-based metric such as Return on Equity can lead to.

2.5.2 Solvency II-consistent Economic Capital

Two concepts are key to set up an Economic Capital framework in insurance:

[13]When defining equity in this way, one should be careful as potentially an issue with goodwill recognition may arise. Namely, if the company is quoted, the goodwill, which is the difference between the market value of the company (driven by its share price) and its net assets value, is likely to be reflected in the balance sheet as an asset. This means that the balance sheet's equity is consistent with the market's equity. However, if the company is not quoted, there is no explicit market value of the company, and its goodwill may be not adequately reflected in the balance sheet. In this case the balance sheet's equity is just a rough indication of the shareholder's value of the company, and this can be far from the company's "true" market value.

- Available Economic Capital, as the amount of capital a firm holds by valuing its assets and liabilities on a realistic bases;
- Required Economic Capital, as the amount of capital a firm should hold in order to cover the risks connected to its profile and businesss model.

The economic balance sheet of a firm is composed of 5 main items:

- *invested assets* (A_0): in a Solvency II framework, these are valued on a marked-to-market basis

  > "at the amount for which they could be exchanged between knowledgeable willing parties in an arm's length transaction"[43];

- *insurance technical provision* (TP_0): in general, this item reflects the value of future obligations to policyholders. In a Solvency II framework, technical provisions are valued as "current exit value", i.e.

  > "it should correspond to the amount an insurance or reinsurance undertaking would have to pay if it transferred its contractual rights and obligations immediately to another undertaking"[43]
  >
  > Insurance liabilities are assessed following 2 methods:
  >
  > - as a whole, if their value is directly observable in the market;
  > - as the sum of the Best Estimate (BEL_0) of the present value of the net cash flows arising from the insurance contracts plus a risk margin (RM_t), i.e. the additional amount to be added to the BEL to ensure that a third party would willing to inherit the liabilities, calculated as a function of the cost for the firm to hold the required capital for unheadeable risks related to that liability until run off;

- *other balance sheet items* (O_0): these include Other liabilities (e.g. staff pension schemes and subordinated debt, usually valued according to a mark-to-model approach), Other assets (e.g. Ceded reinsurance liabilities, valued consistently with Gross liabilities) and Net deferred taxes;

- *Available Economic Capital* (AEC_0): this is defined as the available capital at time 0. In a traditional world, this is generically calculated as $(A_0 - TP_0 - O_0)$, thus it coincides with the market capitalization of the firm (i.e. its equity, if it is not a mutual insurer). The Solvency II regulation distinguishes between Basic, Available and Eligible Own Funds (where only Eligible Own Funds can be used to cover the required capital and depends on tiering limits). For the sake of this thesis, these three amounts are set to be equal and corresponding to the Available Economic Capital. Being the net asset value, this item can be interpreted as the financial enterprise value of the firm at time 0;

- *Required Economic Capital* ($REC_{0,\alpha}$): this is the amount of capital that the Regulator expects the company to hold. In general, the Regulator requests this to be lower than Available Capital (in "Solvency I" words, the Minimum solvency margin MSM_0 must be lower than the firm's equity). In a risk-adjusted regime, a well known definition of this is VaR-based (i.e. based on a Value at Risk measure), and thought of as the smallest amount of available capital at time 0 that satisfies the condition that the amount of Own Funds at time 1 (as seen at t = 0) is positive with a probability of α, i.e.

$$REC_{0,\alpha} = argmin_x \left\{ P\left(OF_1 \geq 0 | OF_0 = x\right) \geq \alpha \right\}. \tag{2.17}$$

  The probability α is a parameter defined by the subject who requires economic capital. If the subject is the Board, then α denotes the Risk Appetite of the firm. Note that the Solvency Capital Requirement (SCR) defined in the Solvency II regime can be thought of as the Required Economic Capital where the confidence level α is set to 99.5%. This is an implicit definition of the SCR ensuring that if the Own Funds at t = 0 are greater or equal to the Solvency Capital Requirement, then the probability that the Own Funds at t = 1 is positive is at least 99.5%;

- *S-II Surplus* (S_0): The difference between Available Economic Capital and the Required Economic Capital represents the firm's Surplus. This is the maximum amount that can be distributed back to shareholders.

Both Available and Required Economic Capital can be used as the capital metric to serve as a denominator of a performance measure, as both provide an economic, realistic view of performance, both can be consistently defined at various granularity level (so called "capital allocation", although this is not always straightforward to do, as we discuss in sub-section 2.5.4) and can be used for both prospective and retrospective analyses.

Remark 2.3 (on Required Economic Capital) A clarification on the concept of "required". Required Economic Capital is usually referred to as a sort of internal view of the Solvency Capital Requirement (SCR), in case any calculation assumption or rule differs from what is prescribed by the Regulator. In this thesis, Required Economic Capital is the Available Economic Capital that the Board asks the Top Management to hold in order to be consistent with their risk appetite.

Note that in Solvency II, firms which use an internal model to calculate the SCR are required to be able to produce the so called "Probability Distribution Forecast", i.e. a function which assigns probabilities to changes in the amount of basic own funds over 1 year time horizon. In these cases, firms have to be able to calculate the Value at Risk corresponding to a different percentile than the Solvency II-prescribed 99.5%.

For instance, internal model firms must be able to calculate the 99.9%-ile of the distribution of ΔAEC, which is the amount of capital they should hold in order to be able to successfully cope with a 1 in 1000 shock. In other words, if the firm's risk appetite is 0.1%, then holding an amount of AEC equal to the SCR would not be enough to fulfil shareholder's appetite, but its Required Economic Capital will correspond to the 99.9%-ile of the distribution of AEC.

2.5.3 Concepts and challenges in calculating, aggregating and allocating required economic capital

Three ways for calculating required economic capital for insurers have been proposed and employed in the industry in the past few years:

- stress-based approaches;
- nested stochastic approaches;
- Monte Carlo with Proxy functions approaches.

In this subsection we will provide a high level overview of the three approaches. Then, in the following subsection, we will illustrate two explicative applications of Monte Carlo with Proxy functions approaches.

Stress-based approach. This approach involves 5 steps:

1. *risk mapping*, which means identifying the m risk factors $\{X_i\}_{i=1,...,m}$ which the firm's available capital depends on, so that

$$AEC_t = f\left(t, \{X_i\}_{i=1,...,m}\right);$$

2. *stress calibration*, i.e. calibrate the desired stress on each of the m risk factors, $\{X_i^*\}_{i=1,...,m}$;

3. *individual capital assessment*, i.e. the impact on Available Economic Capital of each of the m stresses calibrated in step 2

$$ICA_i = \Delta AEC_{t,i} = -\left[f\left(t + \Delta_t, X_i^*\right) - f\left(t, X_i\right)\right];$$

4. *capital aggregation*, i.e. calculating the (standalone) Required Economic Capital REC_k for any desired level of granularity (where k may represent a given legal entity, region or the whole Group) from the single ICAs (so called "modular approach") by using correlation matrices (this is why stress-based approaches are also often referred to as "Variance-Covariance approaches");

5. *capital allocation*, which consists in allocating (means "subdividing") required economic capital to a higher granularity level than REC is calculated at. In other words, diversication benefit should be allocated across the firm's various constituent (e.g. each single business unit, line of business, etc.); capital allocation will be further discussed in subsection 2.5.4.

Example of stress based approaches are:

- *UK's Internal Capital Assessment* (also known as Solvency I Pillar 2), which provides a realistic, internal, risk-based view on required capital;
- *Solvency II Standard Formula* with market-wide parameters, provided to european firms to calculate their SCR, where step 2 is provided by

the Regulator (through standard stresses calibrated on market data) and step 3 is performed using a fixed formula (in general, market-wide parameters are multiplied times a firm's specific volume measure);

- Solvency II Standard Formula with *undertaking-specific parameters*, which is a variant of the Solvency II Standard Formula mentioned above, where the Regulator allows the firm to replace a subset of market-wide parameters with parameters calibrated on firm's data.

There are at least three drawback about this approach:

- the key output is the single REC, it doesn't produce the full distribution of potential losses (the so-called PDF, Probability Distribution Forecast);
- it implicitly assumes losses come from multivariate normal distribution, thus including a constant degree of dependency between risk at all degrees of severity (so that tail dependency cannot be captured);
- futhermore, it assumes losses are linearly dependent on risk factors, however this is often not the case, e.g. for portoflios of participating policies with guarantees, if two risks such as equity and interest rates are stressed together, the impact might well exceed the sum of the single risks.

Nested-stochastic approach. This is considered to be the "purest" approach, and involves the following steps:

1. *risk mapping and calibration*, which involves identifying the risk factors of the firm (similarly to the stress-based approach) and studying their dynamics;
2. *real world simulation*, i.e. simulate large set of S one-year scenarios of the drivers identified in the previous step, i.e.$\{X_{i,s}\}_{i=1,\dots,m;\ s=1,\dots,S}$;
3. *balance sheet simulation*, i.e. re-value the individual components of the balance sheet for each scenario; for many assets and liabilities this has to be done by performing a risk neutral projection to capture all risk characteristics (e.g. for complex derivatives and for life products with

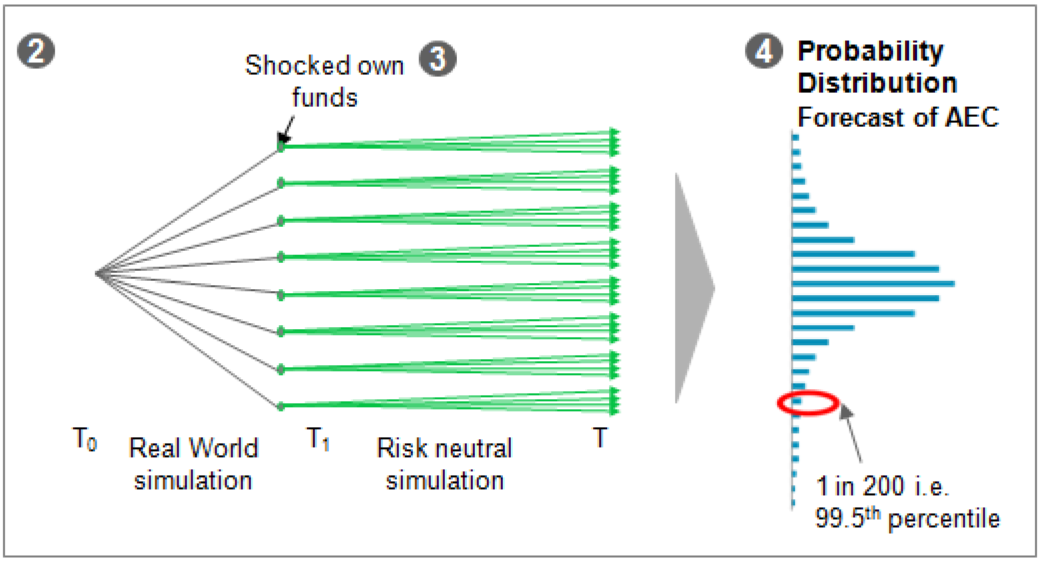

Figure 2.3: Illustration of the Nested stochastic approach

embedded guarantees); the impact on Available Economic Capital of each of the m stresses calibrated in step 2

$$\Delta AEC_{t,i} = -\left[f\left(t+\Delta_t, X_{1,s}, ..., X_{m,s}\right) - f\left(t, X_1, ..., X_m\right)\right] \quad (2.18)$$

with $i = 1, ..., m$; $s = 1, ..., S$;

4. *capital calculation*, i.e. calculating the (standalone) Required Economic Capital REC_k for any desired level of granularity (where k may represent a given legal entity, region or the whole Group); unlike the stress-based approach, this is done by converting the distribution of losses $\Delta AEC_{t,i,k}$ (the "PDF") into a monetary amount, using a pre-defined risk measure; steps 2-4 are illustrated in Figure 2.3;

5. *capital allocation*, similarly to the stress-based approach, although the fact of having the full PDF (rather than the REC only) make more advanced CAM feasible than in the stress-based approach; an example of this is provided in subsection 2.5.4.

As discussed by Bauer et Al. in [4], the key challenge with this approach is in step 3, where a full market-consistent balance sheet must be simulated for each real world scenario. This involves, especially for portfolio having life policies with guarantees, to make N risk neutral projections until year

T (to project cash flows arising from each contract) for each of the S 1-year real world scenarios generated, yielding to a "nested stochastic" simulation which for firms having thousands (or millions) of policies can be prohibitive from a computational perspective. This is even more true considering that REC calculations need to be performed on a timely level and in line with business needs in terms of decision making processes.

Monte Carlo simulation with proxy functions. This approach stands someway in the middle between the Nested-stochastic and the Stress-based approach in terms of accuracy and computational effort; it involves the following steps:

1. *risk mapping and calibration*, similarly to the nested stochastic approach, which leads to the calibration of a joint probability distribution of all the identified risk factors (this also involves calibrating their dependency structure);

2. *proxy function calibration*, aiming to describe the value of the balance sheet item as a function of all risk factors that are shocked in the real world simulation;

3. *real world simulation*, i.e. simulate large set of S one-year scenarios of the risk factors consistently with the distributions and dependency structure calibrated in step 1; a numerical example of how to do this is provided in subsection 3.2.3.1;

4. *balance sheet simulation*, i.e. re-value the individual components of the balance sheet for each scenario based on the calibrated proxy functions; the formula for this is the same as 2.18, however here the proxy functions $f\left(t, X_1, ..., X_m\right)$ have been calibrated in step 2 and don't require any further risk neutral simulation;

5. *capital calculation*, similarly to the nested stochastic approach; steps 2-5 are illustrated in Figure 2.4;

6. *capital allocation*, similarly to the nested stochastic approach.

The key challenges of this approach are summarised in at least two questions: how to calibrate the right proxy function to reflect the dynamics of

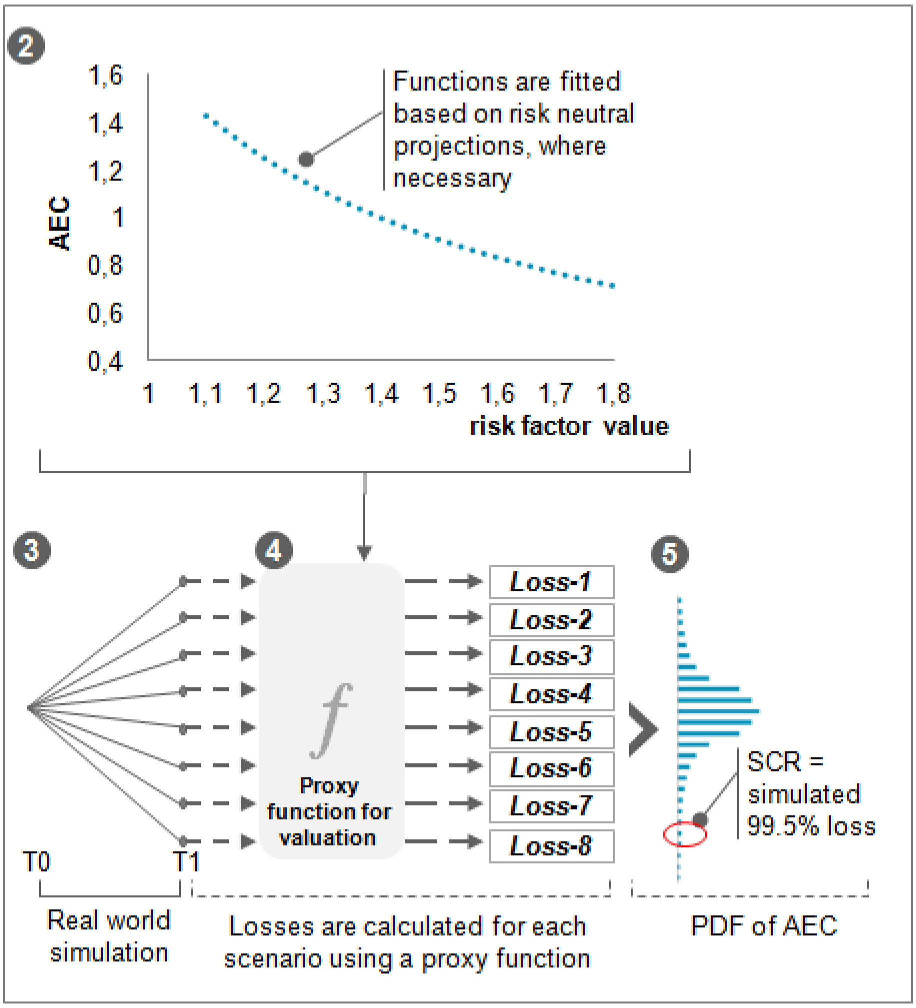

Figure 2.4: Illustration of the Monte Carlo simulation with proxy functions approach

AEC as a function of the mapped risk factors? What degree of "inaccuracy" is considered acceptable for a proxy?

A number of solutions have been proposed in order to perform step 2 above, the most widely known in the industry are:

- *Curve fitting*, which has widely been used since 2009 in the UK market by such players as Aviva, Prudential and Standard Life (see, for instance, Kousaris in [33]), which consists in (1) select a range of stand-alone and combined real world stresses across all Financial, Credit and Underwriting risk factors, (2) calculate the impact on AEC under each stressed scenario (using, where necessary, risk neutral simulations), and (3) fitting a polynomial formula expressing AEC as a function of the risk factors (e.g. using Ordinary Least Squares methodology). The quality of the fitted proxy functions for multi-risk stress scenarios depends on the quality of the scenarios chosen to fit the so-called cross-terms of the function (i.e. reflecting any non-linearity in the joint impact of stresses of two risks on AEC) and hence on the quality of expert judgment involved in the process;

- *Least Square Monte Carlo*, which has recently been implemented by Generali and was firstly introduced in the scientific debate by Bauer et Al. in [4]; this approach consists in (1) generating a large set (e.g. 25,000) of multi-risk real world stresses which are generated using a stochastic engine (as opposed to expert judgment which is used in the curve fitting approach), (2) calculating the corresponding stressed value of liabilities (by generating a small number of corresponding risk neutral scenarios, e.g. 2), (3) fitting a multi-variate polynomial as a "proxy BEL" through a Least-Squares regression. Then, like in the curve fitting approach, we have calibrated (proxy) BEL as the depending variable and the risk factor realizations as the independent variables;

- *Replicating portfolios*, which allows to assess the financial risks which a life insurance Company is exposed to by identifying a portfolio of assets, in a way that its price is consistent to the market value of insurance obligations; from an operational point of view, the portfolio replication allows to transform the "liability object" into an "asset object" (change of metrics), which is possible because, especially for life participating business, insurance contracts often provide similar characteristics financial contracts, especially in terms of market risk profile (this being the reason for this approach to be widely used in Europe by such players as Axa and Allianz for market and credit risks)[19].

Although all these approaches manage to relax many of the limitations of stress-based approaches (e.g., the fact that losses are not necessarily linearly dependent on risk factors), a number of attention points must be dealt with carefully, namely:

- choice of the regression function, which is largely arbitrary, especially in the curve fitting case, where the ability of the curve to replicate the behaviour of AEC depends on the stresses on which the fitting is performed, which is especially concerning given that REC calculation is particularly interested in extreme scenarios;
- unsuitability of the approach to accurately reflect the behaviour of AEC vs. non-financial risks, which is particularly relevant for the replicating portfolios approach;
- simulation error and choice of the number of fitting scenarios, both in terms of real world and risk neutral simulation, in order to calibrate the proxy function (i.e. convergence testing);
- proxy acceptance criteria, thus involving carefully defining materiality thresholds in order to establish when a proxy is "good enough" (be it a curve or a replicating portfolio of assets).

If these limitations are carefully managed, then such proxy models can be deemed to be a valid solution for insurers to calculate the full PDF of their AEC in a computationally feasible fashion. The next subsection shows one of the key advantages of having the full PDF, from a capital management perspective.

2.5.4 Capital allocation and risk appetite: a conditional tail expectation approach

Once calculated and aggregated, capital may need to be allocated (means "subdivided") across the firm's various constituents (e.g. business units).

From a financial point of view, the problem of capital allocation is not trivial. This is because if one calculates the standalone risk capital of each constituent, the sum of such capital is usually larger than the capital of the firm taken as a whole, which leads to the notion of diversification benefit achieved by pooling together the firm's different activities.

Allocation of the total capital to the firm's constituents is then equivalent to allocating the total diversification benefit to them. In a sense, the allocated capital, which is equal to the risk capital of a constituent, minus its allocated share of the diversification benefit, can be considered as a firm-internal risk measure.

The possible purposes of doing the capital allocation exercise might be as follows:

- redistributing of the capital-holding costs (frictional and opportunity) and transferring them back to policyholders;
- regulatory compliance and financial reporting;
- comparison and performance evaluation, in particular:
  - calculate Risk-Adjusted Performance Measures (RAPM) and Return on Risk-Adjusted Capital (RoRAC);
  - identify areas of risk consumption within the firm;
  - inform the remuneration policy in line with business line management (division of a bonus pool);
  - translate the firm's performance results into results of competitors and other industries;
- support to decision making in investment and product proposition (optimizing the capital usage), business expansions, reduction or elimination, and pricing in merger and acquisition activities.

Depending on the purpose of the analysis, firms may allocate capital to:

1. firm's legal (sub-)entities (e.g. subsidiaries or business units);
2. geographies of operation (e.g. different districts, countries or regions);
3. operational functions (e.g. sales, underwriting, investment, back office);

4. risk drivers (e.g. insurance, market, credit, operational risks; or with more granularity: mortality, longevity, expenses, equity, interest rate etc.);

5. lines of business or products (e.g. life, non-life, health; with profits, non-participating, unit linked; term assurance, endowment, annuities, critical illness, long term care etc.)

Remark 2.4 (on Capital Allocation Methods) A capital allocation method (CAM) is any rule, by which the firm will subdivide its aggregated REC to its business units $\{BU_i\}$, assigning to each subsidiary an allocated capital EC_i, such that

$$EC_i = f_i\,(\dddot{X}, \sigma) \tag{2.19}$$

where $\dddot{X}$ represents the whole multivariate distribution of losses for all the n business units and σ is the risk measure used to calculate the overall REC.

A number of desired properties for CAMs have been suggested, e.g. by Denault [18] ('No undercut', 'Symmetry', 'Riskless allocation' and 'Non-negativity') and [10], summarized as:

- Adding-up property, i.e. the sum of allocated capitals should be equal to the total aggregated capital of the firm, as in this case diversification benefit is fully distributed between the BUs;
- Equal Treatment Property, i.e. BUs with the same risk characteristics and the same dependency relationships with the other units should be allocated an equal amount of capital;
- Strong Monotonicity property, i.e. if the risk characteristic of one BU is not increasing, then its allocated capital should not increase either;
- Core Compatibility property, i.e. any subgroup of BUs should be allocated an amount of capital which is not greater than the standalone capital of this subgroup (otherwise it would have an incentive to leave the Group).

Many allocation techniques have been proposed, including the simple proportional method, quantile methods [20], discrete marginal methods, Euler allocation (also called continuous marginal contribution, also discussed in

Scenario	Risk factors			BU_A		BU_B		$Group$	
#	X_1	...	X_m	AEC_s^A	L_s^A	AEC_s^A	L_s^A	AEC_s^G	L_s^G
1	$X_{1,1}$	...	$X_{m,1}$	$f_A\left(X_{1,1},...,X_{m,1}\right)$	$-\Delta AEC_1^A$	$f_B\left(...\right)$	...	$f_G\left(...\right)$	$-\Delta AEC_1^G$
...	...	...	...	...	...	...	...	...	...
S	$X_{1,S}$	...	$X_{m,S}$	$f_A\left(X_{1,S},...,X_{m,S}\right)$	$-\Delta AEC_S^A$	$f_B\left(...\right)$	...	$f_G\left(...\right)$	$-\Delta AEC_S^G$

Table 2.3: Generic set of S simulated losses at Group and single BU level

[36]), Covariance methods, Conditional Tail Expectation [48], Nucleolus [44] and Shapley [46].

In the next paragraph we provide an illustrative example of how the continuous marginal contribution approach can be implemented if we have the full PDF of AEC, to show how this can be linked with reverse stress testing and to the risk appetite framework from a strategic angle.

Continuous Marginal Contribution allocation approach Say that we follow a Monte Carlo with proxy functions approach to calculate REC of an insurer having 2 business units, BU_A and BU_B. We are going to follow the 6-steps calculation process suggested for a Monte Carlo simulation with proxy functions described in the previous subsection.

As illustrated in Table 2.3, a set of S real world scenarios given by the realization of m risk factors $\left(X_{1,s},...,X_{m,s}\right)_{s=1,...,S}$, generated through steps 1 and 3 above; for each of the scenarios, we calculate the value of AEC for each of the BU and for the Group, and therefore we simulate losses (defined as negative changes in AEC), by using proxy functions calibrated in step 2 above.

Hence, at the end of step 4, the output we get is represented in Table 2.3[14].

In this way we are able to calculate standalone REC for Group and for the two BUs (i.e. for each "node" of the Group hierarchy) as the 99.5%-ile of the distributions of losses, consistently with definition 2.17. We are now able to apply an Euler approach in the form of "continuous marginal contribution" in order to calculate the "diversified capital" of the two BUs, i.e. in order to allocate the Group capital to the single BUs.

The idea is to calculate what is the loss for the single BU which leads to a Group loss corresponding to the REC. In other words, for BU_A, we would

[14]Where $\Delta AEC_i^A = \left(AEC_i^A - AEC_0^A\right)$

have:

$$EC_A = E\left[-\Delta AEC^A | -\Delta AEC^G = REC_G\right] \tag{2.20}$$

It has been shown in the academic literature that the conditional tail expectation approach is equivalent to the Euler allocation approach (under certain circumstances described by Tasche in [49]).

Remark 2.5 (on Critical Scenarios).
Note that it is possible to identify the exact scenario $s^* = (X_{1,s^*}, ..., X_{m,s^*})$ which yields to a Group loss corresponding to the Group REC, so that $L^G_{s^*} = -\Delta AEC^G_{s^*} = REC_G$. Such scenario s^* is sometimes referred to as the Group critical scenario, or *killer scenario*.

Hence, considering this specific scenario, it would be possible to identify exactly the contribution of BU_A and BU_B to that specific loss, so that a way to allocate capital (and calculate the so-called **unsmoothed diversified capital**) would be to set

$$EC_A^{unsm} = L^A_{s^*},\ where\ s^* \therefore L^G_{s^*} = REC_G \tag{2.21}$$

However, unsmoothed diversified REC is a very volatile measure, as the unsmoothed diversified capital for BU A, EC_A^{unsm}, could be completely different if we took the 99.501%-ile of the Group losses instead of the 99.500%-ile. Although the two critical scenarios will have very similar Group losses, those losses could be for very different reasons. One scenario could have included a large catastrophe risk event affecting BU_B only, while the other could have been dominated by equity losses in the portfolio of BU_A.

Therefore, in order to avoid distortions due to simulation error, the distribution of conditional losses needs to be smoothed, using smoothing weights in order to calculate *diversified economic capital.*

Smoothed diversified economic capital for BU_A is given by

$$EC^{sm}_{A|G} = \sum_{s=1}^{S} w_{s|G} \cdot L^A_s \tag{2.22}$$

where $w_{s|G}$ is the smoothing weight assigned to scenario s, and L^A_s is the loss for BU_A in scenario s. Clearly, scenarios yielding to Group losses closer to the loss corresponding to the critical scenario s^* will have higher weights $w_{s|G}$ then other scenarios; for instance, if Group is making a profit in a certain scenario s', then its smoothing weight $w_{s'|G}$ is likely to be very close to zero.

Several smoothing techniques have been proposed, however the key difference among them is the statistical distribution used to define smoothing weights, e.g. the Harrel Davis (which uses a Beta distribution) and the Gaussian (which is based on a normal distribution) are among the mostly used smoothing techniques, as described by Harrell and Davis in [27]. The choice among smoothing techniques is closely linked to the convergence testing of PDF of AEC to a "stable" REC.

The conditional tail expectation capital allocation approach have many upsides, including the possibility of:

- directly linking REC allocation to actual real world scenarios, so that allocated capital among different BUs is extremely consistent;
- performing reverse stress testing exercises, thus understanding what sort of scenarios constitutes a "breaking point" for a given BU and, therefore, better identifying mitigating actions;
- linking allocation of capital with risk appetite, given that REC is allocated following a percentile approach which is directly derived by the risk appetite set by the Board (i.e. the choice of α mentioned in subsection 2.5.2).

The approach described above provides a way to make risk measurement, capital allocation, reverse stress testing and risk appetite (including the related escalation procedures, mitigating actions and contingency plans) all consistent in a unique framework.

2.6 A single measure for profitability, risk and capital

The objective of a Risk Adjusted Performance Measure (RAPM) is to provide a uniform measure of performance that management can use to compare economic profitability of businesses with different sources of risk and different capital requirements. As discussed in 2.2.2, the generic representation of RAPM in insurance may have the form of Return on Risk Adjusted Capital (RoRAC, see 2.6) or of Risk-Adjusted Return on Capital (RARoC, see 2.7).

The following two paragraphs discuss how return and capital can be risk-adjusted, using some of the concepts introduced in the sections above. Then, we introduce the metric of Sustainable Free Surplus to show how it can be used to define a dividends policy which considers profitability, risk and capital in a unique holistic view.

Risk Adjusted Return. In performance measurement, the actual earnings are compared against expected (or required) earnings over the measurement period. Economic Value Added is a measure of this comparison, depends on the cost of capital for the considered financial institution and can be defined as

$$EVA_{t,t+1} = Actual\,Earnings - Opportunity\,cost \cdot Allocated\,capital \quad (2.23)$$

which, by defining $\Pi_{t,t+1}$ as the net profit of the firm generated between t and t+1, can be expressed as

$$EVA_{t,t+1} = \Pi_{t,t+1} - CoC \cdot EC_t \quad (2.24)$$

or, in an MCEV framework (by using the 2.11) can be rewritten as

$$EVA_{t,t+1} = OP_{MCEV,[t.t+1]} - CoC \cdot EC_t = EVE_{t,t+1} - EC_t \cdot (CoC - r_{t,t+1}) \quad (2.25)$$

where $EC_t \cdot (CoC - r_{t,t+1})$ is the difference between the target and the actual return on employed capital and can be interpreted as the extra return on capital over the cost of capital.

If EVA is greater than zero, then the business is generating value for investors. The assessment of EVA as a measure depends on the way earnings, opportunity cost and allocated capital are defined, especially in terms of efficiency, communicability, auditability and consistency. Examples are in the market where EVA is already used for "retrospective" applications (e.g. evaluating the historical performance of a business unit) and for "prospective" applications. Furthermore, it definitely is an "economic" (i.e. risk-adjusted) measure.

Hence, Economic Value Added can be used as the numerator of a RARoC measure, i.e. the 2.7 becomes:

$$RARoC = \frac{EVA_{t,t+1}}{C_t}$$

It is also possible to express RoRAC as a function of EVA by using the 2.24, so that the 2.6 becomes:

$$RoRAC = \frac{\Pi_{t,t+1}}{EC_t} = \frac{EVA_{t,t+1} + CoC \cdot EC_t}{EC_t} = \frac{EVA_{t,t+1}}{EC_t} + CoC \quad (2.26)$$

i.e. RoRAC is the ratio of EVA over allocated capital plus the target cost of capital rate.

From the 2.26, we can also infer that (by using the 2.25) that RoRAC is the sum of the ratio of Embedded Value Earning (only related to insurance in-force and new business portfolios) and actual investment return on Shareholder Net Worth

$$RoRAC = \frac{EVE_{t,t+1} - EC_t \cdot (CoC - r_{t,t+1})}{EC_t} + CoC = \frac{EVE_{t,t+1}}{EC_t} + r_{t,t+1}$$
(2.27)

Risk Adjusted Capital. In the previous subsection, we investigated how to define, calculate and allocate Required Economic Capital. If "Required" means "required by the Regulator" then REC equals to the Solvency Capital Requirement. In general, however, the amount of capital which the firm should hold depends on the risk appetite of shareholders, defined by the Board.

Many ways are used in the market to define the Risk Adjusted Capital, e.g.:

- as a multiple of the regulatory-driven SCR;
- as the amount of AEC that would allow the firm to hold a given rating, e.g. AA;
- as the VaR of the Probability Distribution Forecast of AEC with $\alpha >$ 99.5%;
- as an alternative risk measure of the PDF of AEC (e.g. Conditional Tail Expectation).

If the capital management policy of the firm is such that available capital is allocated to each business unit consistently with the risk appetite framework, then we will have that:

- any surplus over the REC is distributed to shareholders at t+1 as dividends, and
- allocated capital for each BU will be equal to their diversified REC (see the 2.22).

However, note that, given that regulatory-driven SCR will always be lower than the risk-appetite-driven REC, in practice firms will not distribute all the dividends to shareholders; in other words, the dividends policy and the risk-appetite framework will always be such that Solvency II excess capital is well above zero, i.e.

$$XC_t = AEC_t - SCR_t > 0, \ \forall t = 0, ..., T \tag{2.28}$$

Sustainable Free Surplus as the driver to define dividends. The ultimate synthesis of the three views is provided by the *Sustainable Free Surplus* generated over a year, i.e. the positive change in $S_t = AEC_t - REC_t$ observed between t and $t+1$. This is the key metric firms are increasingly looking at when setting up their strategy, monitoring their results and remunerating management and shareholders.

Just as an example, let's consider shareholders' remuneration: this is traditionally done through designing a dividends policy which is consistent with the profits expected to be made over the time horizon of the business plan.

In a risk-adjusted framework as the one we described so far (i.e. the Solvency II regime recently come into force in Europe), the dividends policy must be designed not only considering future profitability of the firm, but also (1) the solvency profile of the company (including the quality and structure of its available capital) and (2) the amount of risk shareholders are eager to take on (i.e. their risk appetite).

The increasing use (and the subsequent disclosure) of risk adjusted performance measures (as publicly stated by many insurers to the investors community[15]) is expected to[16]

[15]See, for intance, Zurich 2015 presentation [54]

[16]Care should be taken when interpreting this Sustainable Free Surplus generated, as

1. lead to a more realistic and accurate view of firms' profiles,
2. enable an optimized way to manage the business, and
3. ultimately end up in more transparent information available to the market.

All these aspects will be discussed in the present thesis. The purpose of the next chapter is to investigate how dividends are affected if a company moves from a traditional to a risk-based framework. The implication of such move from a managerial perspective are then discussed in Chapter 4.

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this is not immediately convertible into dividends; this is because a large element of the available economic capial is value of in-force, and therefore cannot be immediately distributed (as is composed of future profit emerging from the in-force portfolio).

Chapter 3

Moving towards a risk-based corporate finance: more volatile dividends

In this chapter we discuss on how moving from a traditional to a risk-based profitability model affects dividends.

In order to do so, we specify a model to define the dividend policy in a market consistent and risk-adjusted framework, according to the following 3 steps:

1. define a traditional approach to project profitability and dividends (section 3.1);

2. extend the approach to make it market consistent and risk-adjusted (section 3.2);

3. run the model and analyze results (section 3.3).

The results of the model are followed by a few considerations on the recent rebate around market-consistent valuations (section 3.4).

In this chapter, we are going to focus on a Non-life insurance case, more specifically, an insurance firm which mostly writes (heavy-tailed) CAT risk. This is driven by the further level of complexity that the financial guarantees embedded in many Life products would introduce. The discussion on how Life business is managed and on the impact of the risk-adjusted framework on dividends for a composite group will be the focus of the chapter 4.

3.1 A traditional approach to project dividends

To illustrate the dynamics driving the profitability of Non-life insurer we will use the framework suggested by *Dacorogna et Al.* in [11].

Three rules and an assumption define the firm's capital management policy (which are consistent with IFRS rules):

Rule_i: annual losses are covered by annual written premiums and, if not sufficient, by equity capital;

Rule_ii: if available capital AEC_t goes below the initial level of equity capital C_0, the company must raise capital at a cost of capital CoC ("cost of raising capital");

Rule_iii: if the whole available capital is not sufficient to settle the annual claims, the company is bankrupt and can no longer write new business;

Assumption_i: there is no time diversification, hence all the profit generated in any given year is taxed and then distributed to policyholders (this hypothesis will be relaxed in the next chapter).

In order to define how the firm generates profits for shareholders we will follow a top down approach, i.e. will start from the end (the wealth of shareholders) to deep dive into the basics of insurance business (premiums and claims).

The wealth of shareholders is directly derived from the capital management policy above: at time t+1 it derives from the capitalization of their previous wealth plus dividends $\delta_{t,t+1}$ paid out minus any capital injected between t and t+1, $N_{t,t+1}$. Hence, it will be given by the following formula:

$$W_{t+1} = [(1 + r_{t,t+1})\, W_t + \delta_{t,t+1} - N_{t,t+1}] \cdot I_{[no\, bankruptcy, t, t+1]} \qquad (3.1)$$

where:

- $r_{t,t+1}$ is equal to the risk free rate, as it is assumed that the investment universe consists of two options to invest money, i.e. in risk-free investments or in the risky CAT-company;

- $N_{t,t+1} = max\{0; C_0 - AC_{t+1}\}$;
- $I_{[no\,bankruptcy,t,t+1]}$ is the indicator function for the event of no bankruptcy between t and t+1, as defined in 3.4;
- $W_0 = 0$;
- the maximum level of dividends that can be distributed is equal to operating profit (net of tax) after a reduction due to the need to *top-up* capital to the original equity capital (and after an increase due to any surplus carried forward by previous year, in case Assumption_i is relaxed):

$$\delta^{max}_{t,t,+1} = \Pi_{t,t+1} - [C_0 - AEC_{t+1}] \quad (3.2)$$

Net operating profit is given by operating profit minus the cost of the capital (if any) that has been injected between t and t+1:

$$\Pi_{t,t+1} = (OP_{t,t+1} - N_t \cdot CoC) \cdot (1 - \tau) \quad (3.3)$$

where:

- τ is the tax rate;
- CoC is the cost of capital, i.e. the return required by shareholders to be willing to invest 1 in the firm;
- the (pre-tax) operating profit $OP_{t,t+1}$ is a function of the technical result and of the capitalization of invested capital and earned premiums.

If operating profit is actually a loss that makes the available capital become lower than equity capital, then the firm must raise capital in order to re-build enough available capital to restore shareholders' value; if, however, the loss is such that the full available capital is not enough to cover it, than, given Rule_iii, the company is bankrupt. In other words, we have the following:

$$OP_{t,t+1} = TR_{t,t+1} + r_{t,t+1}(C_t + P_t) \begin{cases} < -AEC_t, & bankrupt \\ \in [-AEC_t, 0], & necessary\,to\,raise\,N_t\,at\,cost\,CoC \\ > 0, & surplus\,used\,to\,rebuild\,capital \end{cases} \quad (3.4)$$

Finally, technical result is the sum of earned premiums ($P_{t,t+1}$) minus claims' ultimate costs ($Y_{t,t+1}$) and expenses ($E_{t,t+1}$):

$$TR_{t,t+1} = P_{t,t+1} - Y_{t,t+1} - E_{t,t+1} \tag{3.5}$$

While expenses are defined as a combination of a fixed portion of premiums ($e\%$, given by acquisition and liquidation costs) plus a fixed amount (administrative costs), premiums and claims are computed using the following models.

Remark 3.1 In the paper from *Dacorogna et Al.* [11], it is implicitly assumed that all claims are paid as soon as they are reported, and therefore the firm is not exposed to reserve risk (otherwise, technical result would also be driven by the evolution of reserves). We here make the same simplifying assumption, which holds only in case all claims are assumed to be settled as soon as they are reported, so that no claims' reserve needs to be effectively put aside. Consistently, the only source of Non-life underwriting risk we will deal with in the following subsection is Premium risk (i.e. the risk that the premiums are not sufficient to cover claims and expenses).

PREMIUM MODEL: For the first year, we have that premium is equal to the present value of expected value of claims plus expense loading plus cost of required capital:

$$P_1 = \frac{E[Y] \cdot (1 + e\%) + CoC \cdot VaR(X, z)}{1 + r_{0,1}}. \tag{3.6}$$

For the following years, the model is adjusted to reflect the market cycle (e.g. if loss ratios have been consistently lower than 100%, then the market is "softening" and premiums will tend to go below technical premiums), thus we have:

$$P_t = P_{t-1} \cdot \begin{cases} (1-s), & if\, LR_{t-1} < LR_s \ (softening) \\ 1, & if\, LR_s \leq LR_{t-1} \leq LR_h \\ (1+h), & if\, LR_{t-1} > LR_h \ (hardening) \end{cases} \tag{3.7}$$

where:

- LR_{t-1} is the historically observed ratio of claims over premium for the previous year (loss ratio at time $t-1$);

- LR_s and LR_h are two fixed thresholds of below (above) which a softening (hardening) of the premium by the factor s (h) takes place.

Claims model: Given that the company mostly writes heavy tailed CAT risks, annual aggregate claims are assumed to follow a lognormal distribution:

$$\begin{cases} Y \sim LN\left(\mu, \sigma^2\right) \\ \mu = ln\left[VaR\left(Y_t, z\right)\right] - \sigma \cdot \Phi^{-1}\left(z\right); \; \sigma = \sqrt{ln\left[1 + CoV\left(Y\right)^2\right]} \end{cases} \tag{3.8}$$

where:

- $\Phi^{-1}(z)$ is the inverse cumulative distribution function of a standard normal distribution, and
- $CoV(Y)$ is the coefficient of variation, $CoV(Y) = {}^{std(Y)}/_{E(Y)}$ and reflects the underwriting policy.

In the next section we show how this framework can be extended to reflect a risk-adjusted view of the market to build a profitability model based on Economic Capital.

3.2 Extension to an Economic Capital framework

There are three main limitations to the traditional framework described in the previous section:

- it does not properly reflect market dynamics, assuming that a flat risk free interest rate is to be applied to premium and capital invested in the market;
- it does not take into account the change in Required Economic Capital over one year;
- it assumes no time diversification, so that the firm's top management has little freedom to manage the dividends flow.

In this section we propose a way to overtake these limitations by introducing four components:

- a market model to capture the dynamics of the asset portfolio;

- a dependency structure between CAT Risk and Market risks;
- a simplified definition of the Required Economic Capital;
- a dividends' realization strategy.

3.2.1 Modelling the asset portfolio

In order to perform a market consistent valuation of risky portfolios, a model must be defined to be able to capture the dynamics of all the d relevant risk factors which may impact the value of the N contracts composing the portfolio.

Such market models typically assume that investors can trade in a frictionless, continuously open financial market where arbitrage opportunities are made impossible by market players, who are rationale (i.e. profit maximizers), knowledgeable and price takers. Given that asset modelling is not the core focus of this work, we will consider a simple portfolio composed by 2 types of contracts:

- interest rate sensitive (e.g. bonds), exposed to interest rate risk;
- stocks, exposed to equity risk.

The Cox, Ingersoll, Ross (CIR) model is an example of model used to capture interest rate risk in bond portfolios. It is a mean reverting square root able to capture the dynamic of the spot rate r_t keeping consistency over a multiple years timeframe

$$dr_t = f_r\left(r,t\right)dt + g_r\left(r,t\right)dZ_{r,t} \tag{3.9}$$

where the drift is $f_r\left(r,t\right) = \alpha\left(\gamma - r_t\right)$, representing the long term rate of return, and the diffusion factor is $g_r\left(r,t\right) = \rho\sqrt{r}$.

Key hypotheses of the model are that the spot rate is non-centred-chi-square-distributed, hence the spot rate is assumed to be non-negative. In recent times, such assumption has been challenged by the market, given the prolonged low interest rates enviroment experienced following several quatitative easing by US' Federal Reserve bank, UK's Bank of England and EU's European Central Bank, leading to the diffusion of models based on market-observable quantities (e.g. LIBOR forward rates). Such models (e.g. the LMM or LIBOR Market Model, see [6]) work reasonably well even in stressed market scenarios, however they are inherently exposed to market manipulation and distortions (see the 2012 LIBOR scandal, manipulated by Barclays starting from 2005).

Equity risk can modelled using an extension of the Black and Scholes formula, aimed at modelling changes in stock prices:

$$dS_t = f_S(S,t)\,dt + g_S(S,t)\,dZ_{S,t} \tag{3.10}$$

where $f_S(r,t) = \mu S_t$ and $g_S(S,t) = \sigma S_t$.

The B-S model assumes that S_t is lognormally distributed with parameters $\left(\mu - \frac{\sigma^2}{2}\right)\tau$ and $\sigma\sqrt{\tau}$, and the risk market price is equal to $q(S_t,t) = \frac{\mu - r_t}{\sigma}$.

The correlation between the processes of spot rates and instantaneous changes to stock prices is modelled using an instantaneous correlation coefficient $\eta = \rho^{rS}$, so that their covariance is

$$Cov\left[dZ_t^r; dZ_t^S\right] = \eta dt.$$

In this market framework (as shown, for example, by De Felice and Moriconi in [13]), the asset fund performance A is given by jointly modelling stock and bond prices, by solving the following differential equation:

$$\frac{\delta A}{\delta t}+rS\frac{\delta A}{\delta S}+\frac{1}{2}\sigma^2S^2\frac{\delta^2 A}{\delta S^2}+\left[\alpha\left(\gamma-r\right)+\pi r\right]\frac{\delta A}{\delta r}+\rho^{rS}\sigma S\rho\sqrt{r}\frac{\delta^2 A}{\delta r\delta S}+\frac{1}{2}\rho^2 r\frac{\delta^2 A}{\delta r^2}=rA \tag{3.11}$$

Therefore, based on the instantaneous dynamic above, the portfolio return will be calculated on an annual basis as $r_{t,t+1}^{ptf} = \frac{A_{t+1.t} - A_t}{A_t}$.

3.2.2 Modelling the dependency between market and underwriting risk

In order to aggregate risk a dependency structure must be introduced. The goal of the exercise is to identify how the factors driving two different risk categories move together. For instance, in the Life insurance business, if interest rates go significantly up then most likely policyholders will tend to exit their old contracts (especially if these have fixed yield which aren't linked to market rates) to invest their money in securities offering more favourable terms; in this case we observe a positive correlation between interest rate risk and lapse risk.

Given that insurers aim to achieve a holistic view on their risk profile, which consider all the risks they are exposed to (and are, by the way, explicitly requested to do so by the Regulator[1]), then an analysis on the dependency structure must be performed.

In the Non-life example discussed above, the need arises to investigate the dependency between underwriting and market risks. In this context, underwriting risk is assumed to arise from catastrophe risk, i.e. the risk of losses/ adverse changes in the value of liabilities arising from extreme Non-life events in a one-year time horizon.

Before starting a quantitative correlation analysis, the process of investigating the dependency structure between a pair of risks usually involves a qualitative assessment aimed at better grasping the suble connection that might exist between the two risks. This can be done by discussing the following three questions:

- Do changes to market scenario impact CAT events?
- Do CAT events impact the market scenario?
- Are there other factors that may cause CAT events and changes to the market scenario move together?

Regarding the first and third questions, it seems reasonable to assume that market scenarios or other risks do not directly impact CAT events, given that these are ofter considered a "force majeure", unpredictable by their nature.

Regarding the second question, although it would sound intuitive that the occurrence of CAT events tend to lead to negative variations in the market scenario, historical observations look like such relation is not statistically significant, as can easily shown by comparing the twenty largest insured losses from 1970 to 2010 reported by Swiss Re Economic Research with the equity index of the location of each catastrophe and with the MSCI world (as the global equity index)[2]. However, given that the time series used in

[1] IVASS, Regolamento 20 (2008 updated in April 2014), states that "firms must understand the nature of their mapped, their roots and potential correlation, the potential or necessity to control and the effects they can yield to"

[2] The daily, monthly, quarterly and yearly returns after the date of the catastrophe were analysed

this analysis is not long enough (<40 years) to capture CAT events occuring in a 1-in-200 (99,5%-ile) adverse scenario, it is reasonable to assume a 25% correlation, which is indeed consistent with the calibrated correlation in the Standard Formula.

Furthermore, in order to allow a Monte Carlo simulation of real-world scenarios, a two-factors Gaussian copula was used, calibrated with 25% correlation between the two risk factors (CAT and Market risks).

The process of generating a set of real world scenario simulation in order to calculate economic capital and project dividends is described in the following sub-section.

3.2.3 Calculating the Required Economic Capital

The minimum capital will not be anymore only derived as the original equity put aside by investors. Consistently with the capital and risk measures introduced in sections 2.4 and 2.5, it will now be defined as the Required Economic Capital, which can be approximated as the Value at Risk at a 99.5% confidence level of the technical result over a 1-year projection period (as long as the assumption holds that the tail of reserve risk is not material).

In general, the calculation of Economic Capital consists on four steps:

- generate a set of real world scenarios;
- simulate, for each scenario generated, the value of each balance sheet item and of the 1-year technical result (profit or loss);
- calculate the percentile and the SCR;
- recalculate the projected dividends under different scenarios.

3.2.3.1 Real World scenarios generation

Generating S real world scenarios using a copula involves finding the joint distribution of a set of n risk drivers. This can be achieved through the following algorithm:

1. generate S realizations of n standard normal distributions. It is necessary to make a choice on the random number generator (in this example we used the Mersenne Twister algorithm).

$$\{(z_1, ..., z_n)_s\}_{s=1}^{S}, \; Z_i \sim N(0,1) \; i.i.d.$$

2. apply the selected copula without specifying the desired marginal distribution to calculate a set of n normal random variables ("Risk Drivers") having the desired dependency structure. An example of how to do this is provided by *McNeil et Al.* in [36]. Here the choice must be made to choose and calibrate the copula (in this case, a gaussian copula with a correlation coefficient of 25% is used). We therefore define the following copula function:

$$C\left[F_1\left(z_1\right), ..., F_n\left(z_n\right)\right] = F\left\{F_1^{-1}\left[Z_{0,1}\left(z\right)\right], ..., F_n^{-1}\left[Z_{0,1}\left(z\right)\right]\right\} \quad (3.12)$$

   where F is the desired multivariate distribution, $Z_{0,1}$ is the cumulative distribution function of the standard normal distribution and $F_i^{-1}(x)$ is the desired marginal distribution. Using this formula (known as Sklar's Theorem) allows the problem of specifying a complex multivariate distribution to be decomposed into the problem of specifying a choice of copula and a choice of marginal distributions for each risk factor[3]. In the case of a Gaussian copula this step consists in applying the Cholesky decomposition to the correlation matrix (which should be positive semi-definite), and then using the Cholesky matrix to transform the uncorralated variables into correlated variables; in the following numerical example we used the algorithm proposed by Rebonato in [43];

3. apply Marginal Transformation (in this case empirical loss distributions) to calculate a set of S realizations (in this application $S = 1,000$) of n (here $n = 2$) correlated risk factors (i.e. Real World scenarios). So that we have

$$X_i = F_i^{-1}\left[Z_{0,1}\left(z\right)\right] \quad (3.13)$$

   In this case, the marginal distributions are:

   (a) a lognormal distribution as the CAT risk driver;

   (b) an empirical distribution of asset returns as the market risk driver, simulated using a two factor market model.

[3] A wealth of literature now exist on this topic, see for example *McNeil et Al.* [36] for an introductory description of a variety of copulas and *Marshal et Al.* [34] for a focus on the use of Gaussian and T copulas

In other words, in step 2 above a "risk drivers scenario set" is generated, describing the full dependency structure. All risk-drivers are standard-normally-distributed. In step 3, risk factors are then attached to the risk drivers to create a "risk factors scenario set", having the appropriate marginal distributions. Note that multiple risk factors can be attached to a single risk driver; in these cases, the marginal distributions of each risk factor can differ, however the risk factors will be 100% correlated. For instance, we may have that the exchange rate related to two different currencies may be modelled as two different risk factors, however if one of the two is linked to the other one (e.g. for monetary policy constraints), then they are 100% correlate and might both be linked to the same underlying risk driver.

3.2.3.2 Profit/Loss simulation

Using the profitability formulae 3.4 and 3.5 previously defined, a set of $S = 1,000$ profits and losses can be simulated for each of the 1,000 real world scenarios generated.

3.2.3.3 REC calculation

Required Economic Capital is calculated based on the set of $S = 1,000$ simulated losses, using some sort of distribution-based risk measure. Care should be taken with regards to minority interest and fungibility rules, especially in the case of a Group calculation. On a pure Solvency II basis, losses are defined as the difference between basic own funds at time $t = 0$ and basic own funds in the simulated real world scenario. In this case, the REC is defined as the 99.5%-ile of the empirical distribution of the simulated technical result.

Remark 3.2 When dealing with distribution's "tails", as it is the case when calculating REC using a VaR approach through a Monte Carlo simulation, attention should be paid to ensure that convergence is achieved. Even if performing a proper convergence study is out of scope for this analysis, a convergence test has been performed by repeating the REC calculation by setting $S_1 = 10,000$, $S_2 = 50,000$ and $S_3 = 100,000$, and verifying the change in REC was below 5% and marginally decreasing with S_i.

3.2.4 An EC-adjusted dividends model

This subsection shows how formulae described in 3.1 are adjusted in an Economic Capital framework.

First of all, the level of dividends that can be paid out also depend on how required economic capital moved. For example, even if net profit was zero and available capital was unchanged, then the firm would still be able to pay out dividends up to any negative change in the required economic capital. In other word, the 3.2 changes into the following:

$$\delta^{max}_{t,t,+1} = \varsigma \left[\Pi_{t,t+1} - (AEC_t - AEC_{t+1}) + (RAC_t - RAC_{t+1})\right] \tag{3.14}$$

where ς expresses the dividends strategy of the management, which will be further discussed in chapter 4.

Furthermore, the operating profit also changes to consider that:

- investment return from premiums and capital is a portfolio return rather than a risk free return;
- asset return $r^{ptf}_{t,t+1}$ and claims are modelled together.

In other words, the 3.4 becomes:

$$OP_{t,t+1} = TR_{t,t+1} + r^{ptf}_{t,t+1} C_t + r^{ptf}_{t,t+1} P_t \begin{cases} < -AEC_t, & bankrupt \\ \in [-AEC_t, 0], & necessary\,to\,raise\,N_t\,at\,cost\,CoC \\ > 0, & surplus\,can\,be\,used\,to\,rebuild\,capital \end{cases} \tag{3.15}$$

3.3 Results: more volatile dividends

This subsection is dedicated to the results of an application defined in the framework defined above.

The assumptions of the simulation are summarized in in Table 3.1.

In terms of CAT risk modelling, the aggregated claims' amount has been modelled by using a lognormal distribution, parameterized in four different ways reflecting the firm's underwriting policy, as summarized in Table 3.2.

Item	Value	Comments
CoC	10%	
$e\%$	0%	Premiums are defined net of expenses
C_0	10M	
r_f	3%	Risk free rate (annual discounting)
τ	25%	

Table 3.1: Hypotheses of the model

U/W policy	CoV	μ	σ	$E(Y)$ (M)	$StDev(Y)$
A	0,1	0,831	0,066	2,300	0,862
B	1	-0,413	0,549	0,769	1,086
C	10	-2,647	1,416	0,193	0,772
D	20	-3,156	1,613	0,157	0,770

Table 3.2: Potential claims' distributions under four different underwriting policies

Based on the input above, we calculated a set of 1,000 simulations of 5-years patterns of:

- claims amount;
- premium in-flows, calculated on the model specified in the 3.6;
- asset returns.

The 1,000 simulations are real-world scenarios, if the model's assumptions hold. This is because a Gaussian copula was used in order to define the joint distribution of claims' amounts (affected by CAT risk) and asset returns (affected by market risk), following the Gaussian algorithm defined by *McNeil et Al.* in [36].

Figure 3.1 shows the difference between traditional vs. the EC-driven profitability models of the firm's simulated operating result projected for 5 years in two cases:

- using underwriting (U/W) policy B (rather conservative), having a coefficient of variation of 1;
- using U/W policy D (rather aggressive), having a coefficient of variation of 20.

In the figure, we show 4 percentiles of the distributions of projected results, i.e. the 0.5% (“1 in 200” adverse event), the 10% (“1 in 10” adverse event), the 50% (the “expected” event) and the 90% (the “1 in 10” favourable event).

Results show that:

- the firm still makes profits in a 1 in 10 adverse event using both U/W policies;
- if we move from a prudent to an aggressive U/W policy, the distribution of operating results get “squeezed” beyond the 10%-ile, i.e. the difference between profit made in a 1 in 10 adverse event and a 1 in 10 favourable event is smaller in U/W policy D than in U/W policy B;
- in an EC-driven model, operating results tend to be higher than using the traditional approach, especially in adverse scenarios; this is related to the following complementary effects:
  - the introduction of a dependency structure among the risk drivers leads to stabilizing the result, reducing extreme losses, and
  - the market model tends to have a positive impact on returns compared to risk free returns.

However, when the two models are compared using projected dividends, as shown in Figure 3.2 we find that:

- the firm cancels dividends only in a 1 in 200 adverse event in both scenarios and using both the models;
- dividends are much more unstable in an EC-driven model - namely, in year 2 and 3 using an EC-driven model allows paying more dividends, while in year 4 and 5 the stream of dividends drops.

We conclude that, even if using a realistic economic capital model allows to

- mitigate the risk of extreme operating losses, and
- recognize profits to shareholders on a more timely basis,

nevertheless, the dividends' flow becomes much more volatile, and thus makes it necessary to actively identify capital management plans and contingency actions.

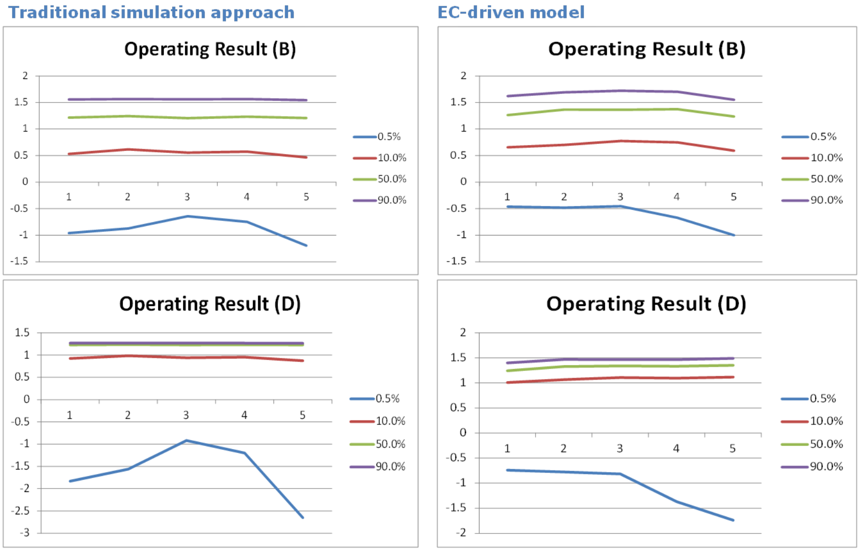

Figure 3.1: Operating profit projected for 5 years tends to be more stable under extreme scenarios in an EC-framework independently of the risk profile of the firm (M)

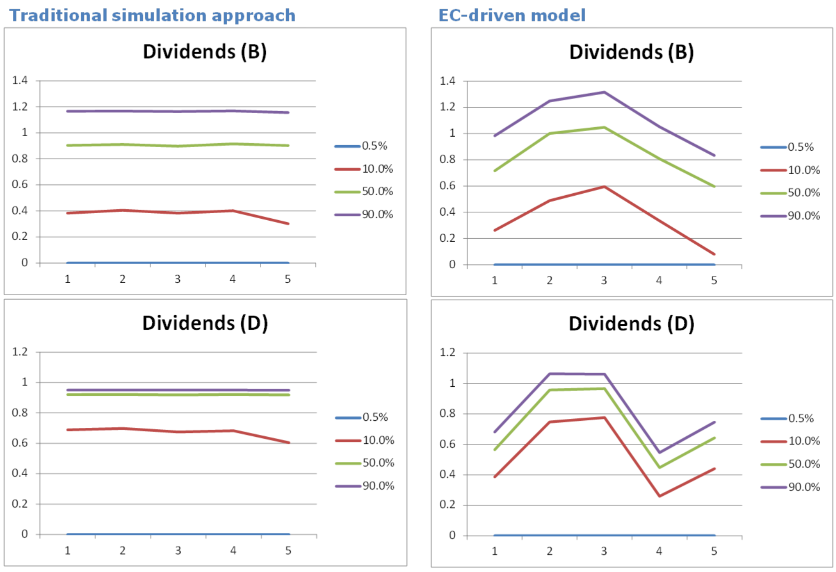

Figure 3.2: Dividends get more volatile due to the pro-cyclical effect fostered by the SCR (M)

3.4 A few considerations on market consistent valuations

Evidences shown in this chapter are just results from a simulation study, and are not aimed at demonstrating that these results are consistently achieved or observed in the market. However, this simulation study leads to draw a few conclusions which are important in a game changer event like Solvency II:

- dividends tend to be more unstable if the balance sheet is valued on a market consistent basis, depending on the market scenario;
- the calculation of projected market consistent balance sheet (including the required economic capital) can be extremely intensive (especially for firms writing policies with financial guarantees, where the nested stochastic problem is more relevant); hence, a trade-off between calculation performance and modelling accuracy must be shought;
- it is very key that management properly understand the models and their output and are able to act as a consequence, identifying the actions able to adjust the firm's strategy towards business and risks, by ordinary actions (e.g. defining the dividends policy), extraordinary actions (e.g. driving the M&A activities) and all the other business initiatives that can be proposed (product structuring/pricing, strategic asset allocation, etc.).

Such considerations are in line with the comments of one of the main characters of the latest insurance industry debate, i.e. Tidjane Thiam, who, in one of his final conference call as CEO of Prudential plc, highlighted two areas of concerns in Solvency II:

- the 2008-2009 global financial crisis showed that market consistency doesn't really work because of the pro-cyclicality within a Solvency II valuation model;
- valuing insurance liabilities using a risk free curve during a period when monetary policy had driven interest rates to exceptionally low levels, threatening the ability of insurers to continue to provide retirement solutions to Europe's ageing population, and a solvency test would

> force insurers to liquidate risky assets at depressed prices in response to a market crisis, increasing systemic risk at a time where the long-term nature of insurance assets and liabilities should be a source of stability.

However, as another relevant figure of the current debate on market consistent valuations demonstrates in [52], it could be argued that

> "Some in the industry characterize market-consistent valuations as "too volatile" and not reflective of the long term economics of the business. But what if market-consistent approaches better reflect the way that our shares are actually valued [by investors]? In this case, value managers who do not like either the volatility in the measures or in their share price should address the underlying business model rather than shoot the messenger".

In the context of such a debate, the purpose of the next chapter is to discuss how in a market consistent, risk-based world, the increased instability arising from the market can be actively managed by firms' top management by consistently steering business, managing risks and choosing modelling techniques in an holistic risk-adjusted strategic framework.

Chapter 4

Risk-based strategies to steer the company: A new hera in strategic planning

In Europe, Solvency II requires[1] that any firm "should take into account the results of the ORSA[2] and the insights gained during the process of this assessment in at least:

- its business planning;
- its capital management;
- its product development and design."

This sets the ground for a new way in which firms should set up their strategy and plan/monitor their business. In this chapter we are going to:

- recap the key ingredients necessary to perform a business planning exercise (section 4.1);
- explore how management actions and intiatives can be assessed and selected in a risk-adjusted framework by using an Economic Capital model (section 4.2);
- discuss how firms can manage capital and define a dividends policy coherently with their risk appetite (section 4.3);

[1] EIOPA Guidelines [21]
[2] Own Risk and Solvency Assessment

- propose a new approach to allow for risk in product pricing in Non-life business (section 4.4).

Note that the framework described in this chapter has been used for training purposes on many levels, namely:

- actuarial and business students;
- professional trainings for non-executives;
- laboratory for managers and executives.

4.1 The strategic planning process

Strategic planning is a key phase in which the Board of Directors formally sets the strategy they want the company to pursue and present it to shareholders and to the market in general. The process leading to business plan sign off is also the opportunity for the Top management to set up, propose and get approved the various initiatives they want to foster in the company to the Board.

Traditionally, three ingrediends are considered to produce a business plan:

- *market position*, i.e. the position of the company in the market context. This involves analysing both qualitative and quantitative factors, such as:
  - the history of the company, e.g. how long has it been active in the market, in which geographies, writing which business lines etc.;
  - the firm's brand and reputation, e.g. areas which the firm's stakeholders consider as strenght or weaknesses (where firm's stakeholders are shareholders, policyholders, supervisory authorities, the market in general);
  - the core values of the company, sometimes formalized in internal regulations, e.g. whether the company aims to be particularly focused on businesses of a specific geography (e.g. factories of a region)/ a specific sector (e.g. agricultural), or is willing to deal with public welfare (e.g. formerly state-owned insurers) or

to push on the innovation side (e.g. wants to be perceived as the high-tech insurer);

- the client base, e.g. whether the policyholders are households or corporates, old or young retail;
- the distribution network, i.e. whether products are distributed through agencies, broker, bankassurance or by direct online business;
- the volume and structure of the balance sheet at time 0 compared to peers;
- the split by line of business of premiums and comparison with the market.

• *key market trends*, meaning the main topics which are being discussed in the market or the key evolution of the industry expected in the next few years. As an example, market trends which are being discussed in the market at the time of writing were:

  - the evolution of the regulatory landscape (e.g. given by the roll-out of Solvency II, the evolution driven by Mifid 2 and the evolving fiscal policies on products and distribution);
  - life product innovation (e.g. decreased attractiveness of unit linked life product in a low interest rate environment, new customer needs given the increased longevity, etc.);
  - ALM and asset management evolution (e.g. in terms of more evolved asset allocation strategies);
  - telematics (meaning the use of technology to prevent and manage non-life technical risks);
  - digital and distribution (e.g. the so-called multi-channel distribution);
  - Big Data (to support decision making and pricing processes)

• *strategic targets* in terms of

  - growth (e.g. premium volumes), and
  - profitability (e.g. measured as Return on Equity).

Traditionally, strategic planning was the process of analysing the three set of ingredients above and translate them into a single picture providing all the business initiatives aiming to achieve the stated targets. The key additional ingredient firms will nowadays need to allow for is risk, which is commonly measured in terms of solvency (in the sense in which it was defined in chapter 2). Risk can be allowed for in two ways:

- as a constraint, e.g. through the definitions of limits on a number of business metrics;
- as an additional target, i.e. by defining a Risk Appetite which the firms should aim to be aligned to.

Such ways are very closely linked to each other, however the "spirit" is very different. In the first case, risk is seen as a constraint which the business structure (be it investments, product desing, underwriting, etc.) should comply with. In the second, risk becomes an additional target, enabling the Top Management to design management actions which best tie the Board aspirations with the firm's capacity.

For example, in the case of ALM, risk as a constraint would be considered by definiting limits in the mismatch between the duration of assets and of liabilities, which is a measure reflecting one of the sources for interest rate risk; risk as an additional target would be to consider the economic value added by the ALM function. A comprehensive assessment of the linkage between risk appetite and strategic planning is provided by the International Actuarial Association in [45].

Given the complex multi-dimensional problem that a strategic plan aims at solving, a sound process should be set up, which makes the involvment of several firm's departments necessary.

The steps to be followed are the following six:

1. set up an initial strategy, by identifying and quantifying the proposed initiatives consistently with market position and market trends;
2. project balance sheet and profitability over a multi-year time horizon, which inlcudes projecting balance sheet items and profitability measures both in a best estimate case (i.e. the one deemed to be the most likely) as well as in stressed scenarios;

3. assess the level of risk embedded in the initial strategy, also in terms of capital absorption as well as of exposure to non quantified risks (e.g. reputational);

4. analyse potential additional actions in terms of business, product and capital initiatives, and consequently update the plan (including the dividends policy);

5. identify potential corrective actions on business initiatives and product and capital plans in case of adverse scenarios (so called contingency planning);

6. pull the final plan together, discuss/ approve it in the Board and communicate it to the market.

The following section present a study aiming to assess a number of potential management actions considering an illustrative composite insurance Group. As such they can be considered as a deep-dive into step 4 in the risk-adjusted strategic planning process defined above.

4.2 Using an EC-model to select management initiatives

In this section we set up a model to investigate on the performance of an hypothetical insurance group in different business circumstances. Then, we use such model to show how RAPMs can be used in practice in order to take management decision allowing for risk. In order to do so, in this section we assess the strategies the top management is considering to take through a model which reflects:

- the fundamental features of the firm, e.g. its company structure, its in-force business and distribution network, its asset portfolio and the dependency structure of the risks it is exposed to;

- the risk and business strategy set up by the Board;

- the rose of potential actions which the management is considering.

The output of the model is a mix of quantitative measures of profitability and risk and qualitative recommendations on actions to take. The model works in four steps:

1. define Group's asset and liability profile at time 0;
2. project profitability and balance sheet under the base scenario;
3. define the management initiatives to be tested and assess them in a risk-adjusted framework;
4. select the optimal actions to be taken and included in the business plan.

In the next sub-sections, we are going to consider each of these steps.

4.2.1 Description of the hypothetical composite Group

Let us consider a hypothetical insurance group that consists of three business units. A *business unit* is defined here as a single legal entity (subsidiary); the structure of the balance sheet as well as the main characteristics of the subsidiaries are provided in the following paragraphs.

4.2.1.1 Starting balance sheet at time t=0

The assumed balance sheet of the group and its subsidiaries at the beginning of the period is summarised in Table 4.1. Under this base scenario we assume that the Group's balance sheet is equally split between the three subsidiaries.

Remark 4.1
We assume that, given that the balance sheet is market consistent, equity coincides with Available Economic Capital. Such capital, however, is not risk adjusted; the risk-adjusted capital will need to be defined as a percentile in the distribution of negative changes in the Available Economic Capital, depending on the firm's risk appetite, following the logics explained in section 2.5.2.

4.2.1.2 Characteristics of the business units

The main characteristics of the business units in terms of risk/return profile are summarized as follows:

Assets (m) , T = 0	**BU1**	**BU2**	**BU3**	**Group**
Stocks	45	45	45	135
ZC Bonds	45	45	45	135
Cash	10	10	10	30
Total	*100*	*100*	*100*	*300*
Liabilities (m),T=0	**BU1**	**BU2**	**BU3**	**Group**
Liability	75	75	75	225
- Technical provisions	70	70	70	210
- Other liabilities	5	5	5	15
Equity	25	25	25	75
Total	*100*	*100*	*100*	*300*

Table 4.1: Illustrative balance sheet at time 0

- *Business Unit 1* is a life subsidiary providing the lowest level of risk and the lowest expected return of all three BUs;
- *Business Unit 2* is very similar to BU1, except it is slightly more risky and earns slightly higher return on a standalone basis. BU2 is also highly correlated with BU1 both in terms of equity return and underwriting results dynamics;
- *Business Unit 3* is a non-life subsidiary providing the highest risk and the highest return on a standalone basis, both in terms of equity returns and underwriting results. BU3 is negatively correlated with the other BUs. In this sense, BU3 can be considered as a "hedging" element within the group that can potentially bring the highest diversification benefit to the group[3];
- *All Business Units* have a partially matched asset-liability position, with only 64% of insurance liabilities being matched by the same duration zero-coupon bonds. The rest of the insurance liabilities are covered by equity, which should be one of the main risk sources for all three BUs.

[3]Negative correlation is assumed between this BU and the other in order to better illustrate the role played by diversification benefit. In practice, we don't refer to any evidence demonstrating that a negative correlation holds between Life and Non-life business units (unless in specific cases such as, for instance, Life BUs which invest in Non-life CAT bonds, or Non-life BUs investing in Longevity swaps).

Parameter	BU1	BU2	BU3
Equity return	4%	5%	6%
Equity std. dev.	10%	20%	30%
Risk free rate (expected return)	2.5%		
Risk free rate (std. dev.)	0.5%		
UW expected return (to liability value)	1.3%	1.5%	1.7%
UW return (to liability value) std. dev.	0.6%	1.2%	2.5%
Duration of ZC bonds (year)	15	15	15
Tax rate	25%		
Cost of Capital	10%		

Table 4.2: Model assumptions related to the risk factors which the Group is exposed to

	Eq.1	Eq.2	Eq.3	IR	Life_UW1	Life_UW2	N-L_UW
Eq.1	1.0	0.8	-0.3	-0.1	0.0	0.0	0.0
Eq.2	0.8	1.0	-0.3	-0.1	0.0	0.0	0.0
Eq.3	-0.3	-0.3	1.0	-0.1	0.0	0.0	0.0
IR	-0.1	-0.1	-0.1	1.0	0.0	0.0	0.0
Life_UW1	0.0	0.0	0.0	0.0	1.0	0.5	-0.5
Life_UW2	0.0	0.0	0.0	0.0	0.5	1.0	-0.5
Non-life_UW	0.0	0.0	0.0	0.0	-0.5	-0.5	1.0

Table 4.3: Rank correlations among the Group risk factors

4.2.1.3 Risk mapping and dependency structure

The modeling assumptions related to assets, liabilities and expected business profiles of each of the business units are summarized in Table 4.2. Note that all returns here are assumed to be net of tax total returns (annual compounding).

Equity returns, IR and underwriting results are based on multivariate normal distribution with the correlation matrix shown in Table 4.3.

An illustrative example of how to calibrate such correlations can be found in the previous chapter (see 3.2.2).

Remark 4.2 In this exercise we assume that:

1. each subsidiary is exposed to a unique equity risk driver : this means that such risk driver will be composed of a basket of equities representing the exposure of the BU. Such assumption is often employed when an internal model needs to be calibrated for Groups having many subsidiaries;

2. interest rate risk is only captured by modelling the value of a generic 1-year risk-free interest rate: clearly this is a simplification, given that a proper interest rate model for the whole interest rate term structure should have been defined (see, for instance, De Felice and Moriconi in [13] for a dissertation on how to allow for interest rate risk in life business modelling); furthermore, all fixed income portfolio is not exposed to credit risk (which is consistent with the standard formula assumption that sovereign bonds are "risk-invariant");

3. technical profit arising from pure life and non-life underwriting risk is modelled using an ad-hoc risk driver for each BU, which aims at reflecting the underwriting policy of the BU; of course, in order to properly model such technical margin an EV-type analysis would be preferable (e.g. in order to isolate technical profit from investment profit), as shown, for example, by De Felice and Moriconi in [14].

Such simplifications are only valid to the extent that the purpose of this exercise is to show how an EC-model can be *used* to inform management decisions and to define a more risk-based business planning, rather than to investigate the most accurate way in order to build such an EC-model.

In order to be used for simulation purposes, this correlation matrix was made PSD (positive semi-definite) by using the "Optimized Correlation matrix method", which is based on the methodology suggested by Rebonato and Jackel in [29].

A matrix is <u>not</u> PSD if it has at least one negative eigenvalue. This method finds a valid (i.e. PSD) correlation matrix C composed of d^2 elements (where d in this case is the number of risk driver, i.e. 7) that is closest to the input correlation matrix A with respect to a distance D defined through optimization weights. Namely, the algorithm minimizes the distance

$$D = \sqrt{\sum_{i,j} w_{i,j} \left(c_{i,j} - a_{i,j}\right)^2}$$

where $w_{i,j}$ are the d^2 elements of a matrix of weights, which here are set to 1, but could be used in order to ensure that some elements of the matrix (e.g. the ones where the experts have consolidated their view) change less then others. The method is widely used in the market, especially for firms whose entity structure and risk mapping makes the matrix extremely big (e.g. where $d = 1,500$).

4.2.2 Projecting P&L and B/S at time 1 under the base scenariob

Given the BS at t=0 and the assumptions of expected values of all the risk drivers (3 for equities, 1 for interest rates and 3 for the underwriting result of each of the BU), we produce the expected profit (or loss) observed during the year as well as the expected BS at t=1. The results are given in Table 4.4:

Note that, consistently with the remark in the previous subsection, the following simplistic assumptions have been used in the model:

- underwriting results are obtained by applied the corresponding expected Underwriting result rate to the corresponding liability values at t=0 (note that this assumption could be relaxed by employing a proxy model such as the curve fitting approach described in 2.5.3);
- the Cash position at t=1 is equal to the sum of four components:
  - the starting cash amount at t=0;
  - return earned on cash during the year (assumed to be equal to the risk-free interest rate);
  - underwriting results earned during the year;
  - tax paid during the year;
- technical provisions are assumed to grow with the risk free interest rate according to a zero coupon bond model with the duration 15 years (also this assumption could be relaxed by employing a proxy model such as the curve fitting approach described in 2.5.3).

P&L (m), year 1	***BU1***	***BU2***	***BU3***	***Group***
UW result	1.2	1.4	1.5	4.1
Stocks	1.8	2.3	2.7	6.8
ZC bonds	1.1	1.1	1.1	3.4
Cash	0.3	0.3	0.3	0.8
Technical provisions	(1,8)	(1,8)	(1,8)	(5.3)
Other liabilities	(0.1)	(0.1)	(0.1)	(0.4)
Operating profit	**2.5**	**3.1**	**3.7**	**9.3**
Tax	(0.6)	(0.8)	(0.9)	(2.3)
Net profit	**1.9**	**2.3**	**2.8**	**7.0**

B/S item (m), t=1	***BU1***	***BU2***	***BU3***	***Group***
Stocks	46.8	47.3	47.7	141.8
ZC Bonds	46.1	46.1	46.1	138.4
Cash	10.8	10.8	10.8	32.5
Total Assets	**103.7**	**104.2**	**104.7**	**312.6**
Technical provisions	71.8	71.8	71.8	215.3
Other liabilities	5.1	5.1	5.1	15.4
Total Liabilities	**76.9**	**76.9**	**76.9**	**230.6**
Equity	**26.9**	**27.3**	**27.8**	**82.0**

Table 4.4: Group B/S projected to time 1 (*Base senario*)

Results in Table 4.4 only show expected P&L and B/S at the year end. This calculation does not make any allowance for riskiness of returns. A simulation based valuation is required in order to estimate the required economic capital as well as other risk-adjusted measures based on it.

In summary, the RAPMs calculation process involves three steps:

1. real world simulation of the Balance sheet at time 1 through a Monte Carlo approach;

2. calculation of both standalone and diversified required economic capital (REC);

3. calculation of the set of RAPMs chosen by the top management.

We describe these calculations in the next three paragraphs.

4.2.2.1 Real-world simulation of the Balance sheet at time 1

Having defined a distribution of the key risk drivers (3 for equities, 1 for interest rates and 3 for the underwriting result), we use these assumptions in a Monte Carlo simulation in order to calculate the profit (or loss) distribution of each of the business units and of the group as a whole. The profit (or loss) distributions obtained are used to calculate the Economic Capital values.

We perform Monte Carlo simulation with 20,000 scenarios. The same random seed is used for different runs of the model under different starting parameters. Under each random scenario, a full P&L and B/S at t=1 are projected, allowing to have a unique total loss distribution for the BUs and the Group.

Remark 4.3 In theory, modelling the Solvency II balance sheet would imply a number of complications, namely in order to calculate the value of financial guarantees embedded in the Life participating business. This problem involves the so-called nested stochastic problem. As discussed in 2.5.3, the industry developed advanced proxy models, such as Replicating portfolios, Least Square Monte Carlo and Curve fitting.
Such proxy models have the great advantage to be usable in a timely fashion, which is extremely important for a model to meet the key requirement for each model, i.e. to be used in the business decision making processes (the so called "Use Test").
On the other side, the loss of accuracy and the contiuous advances made in term of computational techniques and computational power makes it reasonable to believe that in the coming years pure nested stochastic calculations will effectively become a viable solution.
In this application, however, the simplistic assumptions we made makes it possible to calculate the value of each component of the B/S using simple closed formulae approach, and apply it to each of the simulated real-world scenario.

4.2.2.2 Calculation of Required Economic Capital

The amount of economic capital which the firm is required to hold can be based on different risk measures (e.g. VaR, Tail-VaR, etc.) and different risk levels (e.g. percentile values for VaR being 99.5% on a 1 year horizon or 99.9% on a 1 day horizon). The choice of the risk measure and of the percentile may depend on the regulatory constraints or on the firm-specific risk appetite set by the Board. Once determined, Required Economic Capital is used in order to allocate Available Capital to different BUs. In the

Risk measure *(m)*	**Standalone**			**Allocated**			**Group**
	BU1	*BU2*	*BU3*	*BU1*	*BU2*	*BU3*	
VaR 99.5%	8.6	16.0	22.5	4.5	9.4	12.5	26.4
VaR 99.9%	10.9	19.2	26.3	6.0	12.4	14.4	32.8
T-VaR 99.5%	10.1	17.9	24.9	5.4	10.8	14.5	30.6

Table 4.5: REC results

model, we are using Euler allocation method. In case of VaR based EC, Euler allocation is done by applying a kernel smoothing algorithm based on the Nadaraya-Watson kernel estimator (seem for instance, the paper from Tasche, [49]).

Remark 4.4 (on the role of risk appetite) In this exercise, we assume that the appetite of the firm is to hold an amount of economic capital equal to the VaR of the distribution of Basic Own Funds with a confidence level of 99.5% on a 1 year horizon. In a Solvency II world this coincides with the SCR, i.e. the Required Economic Capital. Therefore, in this case the target solvency ratio would be equal to 100% (which is very unlikely in practice, given that most firms are targeting a Solvency II ratio between 150% and 200%). If Available Economic Capital goes above this threshold, than the excedance is paid out as dividends. If, on the other side, available capital goes below the risk appetite, then more available capital is needed, so that if the firm is a holding company it will have to raise capital to the investors, while if it is a subsidiary, then a capital injection by the holding company will be required.

Table 4.5 shows the results of such calculations for our model with the assumed distributions of the risk factors. In this case, we chose Required Economic Capital to be defined as a distributional risk measure, namely the value at risk of the simulated distribution of operating profit between time t=0 and t=1.

4.2.2.3 Calculation of Risk Adjusted Performance

Based on B/S, P&L, EC and CoC values we can calculate the following six key Performance Measures, consistently with the notation introduced in Chapter 2:

	Standalone			Diversified			Group
(m), t=0	BU1	BU2	BU3	BU1	BU2	BU3	
Capital base employed in the performance calculation							
Equity Capital	25.0	25.0	25.0	25.0	25.0	25.0	**75.0**
Economic Capital	8.6	16.0	22.5	4.5	9.4	12.5	**26.4**
P&L values employed in the performance calculation							
Net profit	1.9	2.3	2.8	1.9	2.3	2.8	**7.0**
Cost of capital	(0.9)	(1.6)	(2.2)	(0.4)	(0.9)	(1.3)	**(2.6)**
EVA	1.0	0.7	0.6	1.4	1.4	1.5	**4.3**
Selected performance measures							
RoE	7.4%	9.3%	11.2%	7.4%	9.3%	11.2%	**9.3%**
RoEC	21.4%	14.5%	12.5%	41.6%	24.7%	22.3%	**26.4%**
RARoC	13.2%	9.7%	7.4%	18.8%	18.4%	20.6%	**19.3%**
RARoRAC	11.4%	4.5%	2.5%	31.6%	14.7%	12.3%	**16.4%**

Table 4.6: Performance measures on the base scenario

- Economic Value Added (EVA), obtained as the net profit adjusted for the cost of holding the allocated Economic Capital in the company;
- Return on Equity (ROE), defined as the net profit divided by the equity capital;
- Return on Economic Capital (RoEC), obtained as the ROE by replacing the equity capital with the allocated Economic Capital; this is a form of RoRAC (Return on Risk-Adjusted Capital) in which the chosen RAC coincides with the SCR (i.e. the risk appetite is such that REC = SCR), after considering the allocation of the diversification benefit;
- Risk Adjusted Return on Capital (RARoC), defined as EVA divided by equity capital;
- Risk Adjusted Return on Risk Adjusted Capital (RARoRAC), defined as EVA divided by allocated Economic Capital.

Results are illustrated in Table 4.6.

Remark 4.5 (on prospective vs retrospective analysis) The RAPM results shown above and in the following sub-sections are based on a prospective analysis. Similar considerations could be made by performing a retrospective analysis, in which case profitability actually realised (as opposed to expected) should be taken as input, and then adjusted for the level of risk taken.

Remark 4.6 (on the denominator of the RoEC) In defining the RoEC we used the Required Economic Capital as the denominator, as we would expect in a generic RoRAC measure. In theory, however, it would be more meaningful to replace the REC with AEC; in fact, using the Available Economic Capital would increase the consistency of the RAPM assessment with the budgeting phase, in which top management assigns a budget (and thus, in a risk-based framework, allocates Available Economic Capital) to each single business structure and business unit.
In this exercise, we decided to keep a REC-type denominator rather than evolving it to an AEC-type, because of three reasons:

- Market practice: Firms historically tend to allocate the benefit arising from risk-diversification rather than the actual capital available; while the former is often done by the risk management function, the latter is typically performed by the finance department in the budgeting phase;
- Scientific literature: In literature, capital allocation is usually referred to risk capital allocation rather than available capital allocation (see, for instance, [20, 49, 48]);
- Impact of capital management: If firms had effective capital management plan and procedures, then the actual AEC would constantly coincide with the internallly defined REC, e.g. by
  - having a dividends policy such that any excess of capital beyond risk appetite is paid out as dividends;
  - recovering any capital shortfall thorugh extraordinary capital injections;
  - ensuring that Group capital is allocated to each BUs consistently with risk appetite towards each BU.

4.2.3 Taking management decisions based on a RoEC optimization strategy

In this subsection we demonstrate how a RAPM framework can be used by Top Management to inform important business decisions by looking for maximising firm's RAPM.

For the purpose of this example we have chosen a RoRAC measure, but other RAPMs would be suitable in a similar way.

We start by considering the range of situations we want to investigate; then, for each situation, we show the decisions that would be employed if a ROE-based strategy was followed (i.e. not considering risk) rather than a RoRAC based one (i.e. in a risk-adjusted framework). We also show that optimal business decisions taken on the basis of ROEC and ROE information may be opposite to each other.

In the next paragraphs, we want to study the effect of the following management levers[4]:

1. diversification among Business Units;
2. change exposure to Business Units;
3. change in strategic asset allocation and ALM position;
4. change underwriting and reinsurance policies.

4.2.3.1 Effect of diversification among business units

Although under the Base scenario the balance sheet of the three BUs are identical (see Table 4.1), the risk/return characteristics and hence the risk adjusted performance measures of the three are different (see Table 4.6). Before assessing any new management action, we are going to analyze the current expected RAPM values of the Base scenario (described in Subsection 4.2.1.2) and the contributions that different factors had to this position.

There are two main factors in the base risk position:

- different return/volatility characteristics of equity and underwriting results;

[4]The order of such investigation follows the will to (1) first analyze the status quo in terms of risk profile and diversification effects, (2) then optimize such diverfication benefit through an optimal capital allocation, and, finally, set up optimal (3) asset and (4) liability management strategies.

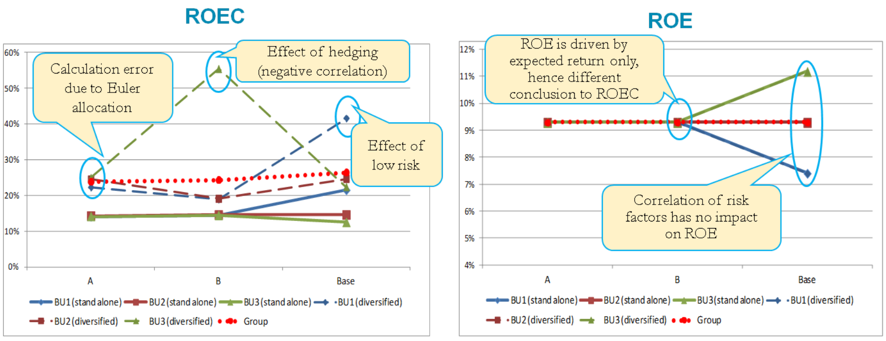

Figure 4.1: Effect of diversification among BUs on ROEC and on ROE

- different correlation assumptions between them.

In order to assess impact of these two factors separately, below we consider two additional scenarios:

A. Identical BUs: Group B/S is kept as in the Base scenario (i.e. it is equally distributed across the three BUs), however the distribution of Return on Equity and of underwriting results is the same (as the ones of BU2) for all three BUs, and all the risk factors are uncorrelated among different BUs;

B. Diversification: Initial B/Ss and distribution of returns are assumed to be as in scenario A, but now the correlation matrix between the risk factors being the same as of the Base scenario (i.e. BU1 and BU2 are positively correlated, while BU3 is negatively correlated with BU1 and BU2).

The third scenario we consider is the Base scenario, as already described in Subsection 4.2.1.2. In particular, we have that:

- BU1 provides lower return and risk, BU2 is in the middle, and BU3 offers highest return and risk;

- BU1 and BU2 are positively correlated, while BU3 is negatively correlated with BU1 and BU2.

The RoEC and ROE profiles of the Group under the three scenarios are shown in the figure 4.1 (note the change on the y-axis scale).

The analysis of the obtained results leads us to a number of comments:

- all three business units provide the same standalone RoEC in scenarios A and B. This is because correlation between BUs has no impact on standalone ECs;
- in the Base scenario, the standalone RoEC performance of BU1 improves due to a lower level of risk, while the corresponding ROE movement is opposite to this;
- on the diversified basis in scenario A, even though the three BUs are absolutely identical in terms of risk/return characteristics, there is still some difference between the ROEC results. This is caused by simulation error under the method of Euler allocation of REC[5];
- the updated correlation structure of scenario B leads the diversified ROEC of BU3 to become the highest of all three BUs (as its allocated REC is the lowest). This is caused by the negative correlation with the rest of the Group. BU3 may be considered as a hedging element of the Group;
- when different levels of risk and return of BUs are introduced in the Base scenario, the least risky BU1 overperforms the other BUs on a ROEC basis. In this case the negative impact of the high riskiness of BU3 has overweighted the positive impacts of its highest return and negative correlation with other BUs
- diversification has no impact on the ROE results. The best BU will always be the one yielding the highest return (i.e. BU3 in our case) regardlessly the level of risk taken or its impact on the overall risk position of the Group.

4.2.3.2 Action 1: Investing more heavily in one of the business units

In this numerical example, the first management action the Top Management is considering is to rebalance the Group's B/S by changing exposures to different BUs.

[5]Despite of the 20,000 simulations used and the kernel smoothing techniques applied, the allocated VaR values will still be largely based just on a small number of simulations that deliver a total loss close to the VaR value. This causes relatively high volatility of the metrics that are based on the allocated REC values.

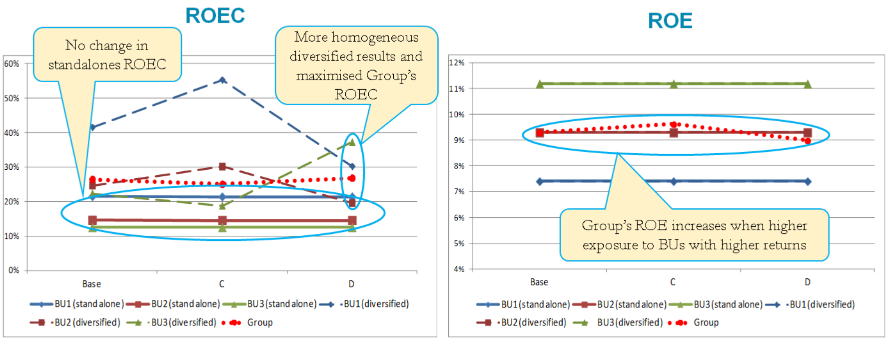

Figure 4.2: **Action 1** - Impact of a changed allocation of resources among the BUs

In practice this can be done e.g. by consolidating or selling out part of the equity of given BUs in order to increase or reduce Group's share in them; or making decision on growth/reduction strategies for some BUs. The two formalised scenarios which the management of the company need to choose from are the following:

C. <u>Increase exposure to the "hedging" BU</u>: The Group increases its exposure to BU3 by 25% and reduces its exposure to BU1 by the same 25% (we assume proportional increase/reduction of all the current balance sheet items for the effected BUs). This decision could be motivated by increasing exposure to a business unit, which is negatively correlated with the rest of the Group, in a hope of gaining more diversification benefit for the Group;

D. <u>Increase exposure to less risky BU</u>: This scenario is opposite to the previous one, as the Group reduces its exposure to BU3 by 25% while increases its exposure to BU1 by the same 25% (again, we assume proportional impacts on the balance sheet items). This decision could be motivated by increasing exposure to the least risky business unit in a hope of decreasing the overall risk of the Group.

ROEC and ROE results for these two scenarios are shown in Figure 4.2, comparatively to the Base scenario (note the change on the y-axis scale).

The analysis of the obtained results leads us to a number of comments:

- as expected, there is no impact on standalone RoEC performance as the balance sheet of the single BUs is just scaled up or down under the two scenarios leaving the ratio between expected return and the standalone REC numbers unaffected;

- under both scenarios the diversified RoEC goes up for those BUs where capital is withdrawn. An interpretation for this may be that when a business unit becomes smaller its unique risk profile does better absorb risks of the rest of the group raising bigger share of the diversification benefit to it. By doing this a business unit is effectively taking a role of the "hedging" element of the Group (in our case it's BU1 in scenario C and BU3 in scenario D);

- Group's RoEC is maximised in scenario D, when investing more on the BU which overperforms the others under the Base scenario (i.e. BU1). Note that in this case the performance of each single BUs in the Group becomes more homogenous;

- on a ROE basis, the conclusion is very different: while standalone performance of single BUs is unchanged, Group's ROE improves when higher exposure is given to BU3 (i.e. the high-yield high-risk choice) and go down in scenario D (i.e. when investing more on the low-yield low-risky BU1).

Based on the above, the optimal decision based on the RoEC results is taken scenario D (i.e. increase exposure to BU1, which had the best performance under the Base scenario). It's interesting that by doing so the RoEC based performance of the most risky BU3 will be also improved as it will deliver more diversification benefit.

4.2.3.3 Action 2. Changing the Strategic Asset Allocation and the ALM position

Say that, following considerations in the previous subsection, the firm's Top Management has opted for Scenario D, thus investing more in BU1. The next management action they are considering is to improve performance of BU1 and BU2 by changing their ALM strategies.

At the moment both BUs invest 45% in equity (different for all BUs), 45% in zero-coupon bonds (ZCB) of the same duration as insurance liabilities, and 10% in cash. Given the insurance liabilities constitute 70% of the B/S for both BUs, their coverage by the perfectly matching ZCBs is only 45%/70%=64%, with the rest of insurance liabilities being covered by risky equities. Management of the Group perceives BU2 as being too risky and wishes to improve its ALM position by holding more ZCBs of matching duration. At the same time, management considers BU1 as being excessively prudent in its investment and operational strategy and would like to explore more profitable opportunities by mismatching asset-liability position even further.

They therefore consider the following three scenarios:

E. Reduce risk profile of BU2: a portion of assets of BU2 previously invested in equity is reinvested in more ZCBs of the same duration as insurance liabilities, so that now they cover 93% of insurance liabilities. The ALM position is therefore improved, having a positive impact on EC, but reducing expected return from the assets;

F. Increase risk profile of BU1: BU2 is changed as in Scenario E, while BU1 is changing its current investment in ZCBs of the same duration as insurance liabilities (15 years) into a shorter term ZCBs (5 years) that are providing additional 2.5% p.a. of return (i.e. doubling the original risk free interest rate earned previously);

G. Mitigate risk for BU1: Again, BU2 is changed as in Scenario E, while BU1 is changing its current investment in ZCBs into other shorter term ZCBs now of duration 10 years that are providing additional 1.5% p.a. of return (i.e. increasing the original risk free interest rate previously earned by 60%).

RoEC and ROE results for these three scenarios are shown in Figure4.3, comparatively to Scenario D that was chosen in the previous subsection (note the change on the y-axis scale).

The analysis of the obtained results leads us to a number of comments:

- increased Risk-Adjusted performance from risk mitigation (BU2): both standalone and diversified ROEC results of BU2, as well as the Group's RoEC result, have been improved when moving from scenario D to

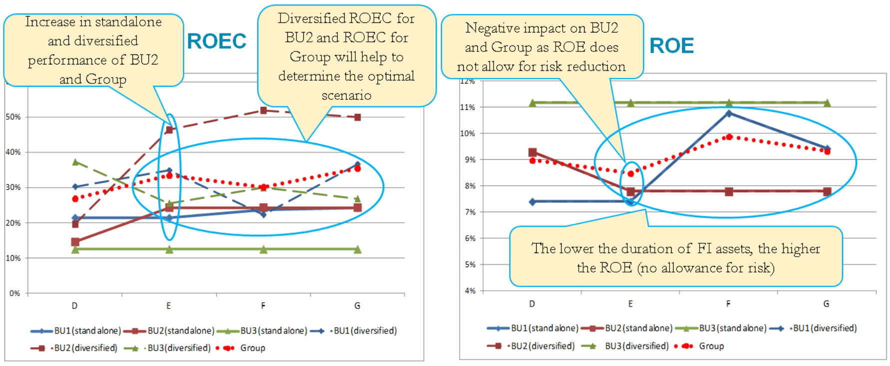

Figure 4.3: **Action 2** - Impact of changing the ALM profile in terms of ROEC and ROE

scenario E. It means that decrease in risk due to improving of ALM position of BU2 is more valuable in terms of RoEC than decrease in returns due to switch from equities to risk free return;

- decreased ROE from risk mitigation (BU2): note that the same action (move from scenario D to E) is assessed as being negative in terms of ROE both for BU2 and the Group's results, as this measure does not allow for reduction in risk, but just registers decrease in expected return;

- RAPM as a measure of the risk/return trade-off: when concerning potential changes made to BU1's ALM, we see that BU1 is steadily improving its standalone RoEC position when moving from scenario E to F, and then from F to G. At the same time, we see that the diversified RoEC result of BU1 and the Group's RoEC result are taking their minimums at scenario F and their maximums at scenario G. This is an important example showing how RAPM (RoEC in our case) can help in determining an optimal strategy in a situation where the alternatives cannot be assessed qualitatively (i.e. one cannot say which of Scenarios E, F, G is "better" based just on their qualitative assessment, as any increase of return in them is compensated by increase of risk in ALM position, which cannot be easily measured without thorough quantitative analysis similar to what we did);

- risk not captured by ROE: again, ROE results don't reflect any change in the level of risk of BU1 in scenarios E, F, G and reflect just changes in expected return.

If the Top Management of the company were making their decisions referring to RoEC-based scenario assessment, scenario G would be chosen as the optimal preferred strategy. Note that if management of the company were basing their decisions just on the ROE results, other choices would have been made.

4.2.3.4 Action 3. Investigating further risk mitigating actions

Having chosen scenario G in the previous step, the Top Management of the company is now concerned about performance of BU3. Despite being the most risky business unit in the Group, BU3 has had the highest diversified RoEC result under scenario D due to its negative correlation with the rest of the group and hence providing the highest diversification benefit to the Group. However, the situation has changed under scenario G after ALM position of BU1 and BU2 have been improved. Now both standalone and diversified RoEC results of BU3 are the lowest among the three business units. It means that the combined return-hedging-riskiness position of BU3 is not optimal anymore and should be improved by some management actions. Given this consideration, the management of the company is considering three alternative scenarios that might improve both BU3's and the Group's performances.

The scenarios considered are the following:

H. Reduce equity risk in BU3: namely, swap 100% of the equity currently held by BU3 to the type of equity held by BU2 (which is less risky and has lower expected return). All other features of BU3's model remain unchanged;

I. Reduce riskiness of BU3 arising from operational activities: namely, change the current business model of BU3 to the less risky business model currently operated by BU2[6]. Such change will lead to

[6] The business model may consist of such elements as types of insurance products written, distribution channels and underwriting policies used, level of expenses born, pricing policies applied and others. We appreciate that in practice changing a business model, or making it equal to some other existing business model in particular, may not be an easy task, and that our example significantly simplifies such consideration for demonstration purposes.

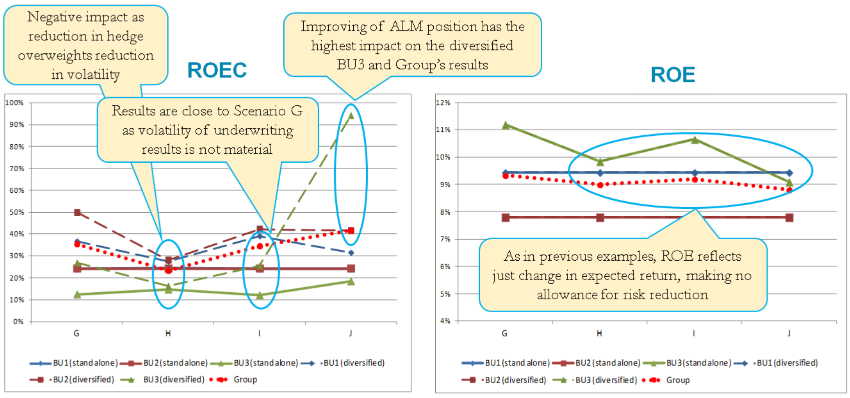

Figure 4.4: **Action 3** - Impact of risk mitigating actions in terms of ROEC and ROE

having the same distribution of underwriting results as BU2 currently has. All other features of BU3's model remain unchanged;

J. Increase asset-liability matching in BU3: finally, reduce riskiness of BU3 that origins from its mismatched assets-liabilities position. Namely, make this a similar swap of part of BU3's equity to matching ZCBs as it was done for BU2 under scenario E. After such change 93% of insurance liabilities (previously it was 64%) will be covered by ZCBs of the same duration (15 years). All other features of BU3's model remain unchanged.

RoEC and ROE results for these three scenarios are shown in Figure 4.4, comparatively to scenario G that was chosen in the previous subsection (note the change on the y-axis scale).

The analysis of the obtained results leads us to a number of comments:

- No major change in standalone performance: on a standalone RoEC basis we can see only some insignificant changes in BU3 performance (while BU1 and BU2 are unaffected). This is because the positive impact of risk reduction under all three scenarios (H, I, J) is largely overweighted by the opposite effect of decrease in expected returns. Diversification benefit is not included in this metric so any change in risk mitigation (or hedging) results is not reflected here;

- Reduced hedging effects: under scenario H (equity swap) we can see deterioration of the BU3's diversified ROEC and Group's ROEC. This is because the hedge (due to negative correlation) that BU3's equity had been providing against risky equities of BU1 and BU2 is not available anymore. This decrease in diversification benefit is not sufficiently compensated by reduction in riskiness of BU3's equity itself (from 30% to 20%) and hence results in negative overall impact for diversified BU3's and Group's ROEC results;

- Immateriality of equity volatility: scenario I (change in operational activities) is much closer to the original scenario G than scenario H with equity swap. The reason for this is that standard deviation of underwriting results under both scenarios (G and I) is not material (2.5% and 1.2% respectively) comparatively to equity's standard deviation (30%). Therefore, although being reduced by more than 50%, effects from volatility reduction and corresponding reduction in hedge have no significant impact on overall ROEC results;

- Material savings arising from ALM in BU3: scenario J shows the best results between all three scenarios as well as a noticeable improvement from the starting scenario G. It can be seen for both standalone and diversified ROEC of BU3, as well as the Group's ROEC. This result is caused by two factors: significant reduction in risk due to ALM improvement (similar effect was seen for BU2 in scenario E), combined with preserving a high diversification benefit due to negative correlation of BU3's equity and underwriting results with the rest of the Group;

- Risk not captured by ROE: finally, as in previous considerations, ROE does not allow for risk and reflects just changes in the expected returns. Therefore, all three scenarios (H, I, J) do have worse results than the under original scenario G, as each of the three scenarios assumes some reduction in the expected return.

Based on the ROEC assessment of the alternative scenarios, scenario J (i.e. improvement of BU3's ALM position) would be the optimal scenario both for BU3 and the Group as a whole.

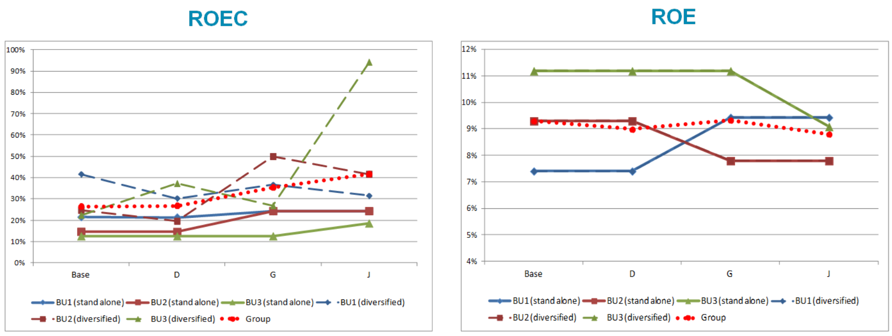

Figure 4.5: **Summary** - Impact of the actions taken in terms of RoEC and ROE

4.2.3.5 Summary of actions taken

In the previous subsections we have considered a hypothetical company consisting of three business units and three different business decisions that company's management was considering. Basing on the RAPM (namely RoEC) assessment of different alternatives, the Top Management has been choosing optimal decisions in each situation.

Below we recall these optimal scenarios and put them on a single graph to demonstrate how company's RoEC position was improving following the corresponding management's decisions:

BASE: We have identical B/Ss, BU1 provides lower return and risk, BU2 is in the middle, and BU3 offers highest return and risk. Also, BU1 and BU2 are positively correlated, while BU3 is negatively correlated with BU1 and BU2.

Action_1: Group reduces its exposure to BU3 while increasing its exposure to BU1 (scenario D);

Action_2: BU1 deteriorates its ALM position seeking for higher investment return, while BU2 is on the contrary improving its ALM position on the cost of return reduction (scenario G);

Action_3: BU3 improves its ALM position similarly to BU2 in Scenario G, leading to an increase in its hedging features (scenario J).

We see that all three decisions on Figure 4.5 lead to improvement of the total Group's performance in RoEC terms. The BUs' results are also improving in average, although show less stable than the Group's results.

Interestingly, when assessing the same decisions in ROE on Figure 4.5, we can see that each decision leads to worsening of both Group's and BUs' performances (apart from Scenario G, in which the changed ALM position leads to higher investment return). Such results are expected given that:

- ROE is reflecting just profitability of BUs with no allowance for the risk taken;
- all optimal decisions taken by the management involve some reduction of company's risk on the cost of a reduced level of expected returns.

The dramatical difference between conclusions driven by RoEC and ROE demonstrates the *importance of having appropriately designed risk-adjusted performance measure to be used as management information in the decision making process.*

We should also note that although we've been using a specific RoEC measure based on EC determined as 'value at risk' (VaR) at the 99.5% percentile, other RAPMs could also have been used and would potentially lead to similar conclusions for our model. Behaviour of different RAPMs in practice, however, can differ due to more complicated models used there. In particular, RAPM results and conclusions based on them may differ when a model has risk factors with heavy tails, especially when their distributions are of different shapes and cannot be scaled (as was the case in our model, which was based on multivariate Normal distribution).

This exercise also showed that a very important role in assessing management decisions is played by the **impact of diversification benefits**, measured at a Group level. This gets particularly relevant in moments of deep regulatory evolution, like the one we are currently witnessing, which is pushing the industry towards a new wave of M&A activity and consolidation, as discussed, for instance, in [51]. An important challenge will then consist in carefully consider the effect of such M&A activities on diversification benefits, i.e. by using models based on appropriately defined RAPMs in order to properly reflect diversification benefits.

4.3 Capital management strategies and dividends policy

As requested by Regulators (see EIOPA guideline #36 in [46], for instance) firms should have a capital management policy, which should include procedures related to at least the following three main features:

- the projection and monitoring of the solvency position, thus including any considerations about tiering (i.e. the quality of funds) and fungibility of available capital (e.g. to monitor the existence of ring fenced funds);
- policy and statements with regards to dividends distribution or cancellations;
- the development of a medium-term capital management plan.

A medium-term capital management plan should cover a time-horizon at least consistent with the business plan time-horizon and include information such as:

- foreseeable capital issuance and solvency projections;
- maturity and/or repayments arising from assets affecting available capital;
- dividends' distribution policy.

To better qualify such concepts, in the next three subsection we:

- define how capital management plans are put together by insurers;
- provide two examples of dividends policy actually used in the market;
- show the results of the case study introduced in the previous section after allowing for capital management actions.

4.3.1 Capital management planning in practice

The capital management plan of a firm lays out how the Top Management aims at ensuring that shareholders' return on capital ambitions are met while observing the Board-set risk appetite. In order to do this, available capital needs to be allocated to the various BUs, so that return on (allocated) capital targets can be assigned to each single BU (so that a clear accountability of targets can be envisaged). To achieve such targets, some capital measures need to be planned and taken into account in the solvency projections. These actions are listed and formalized in firm's capital management plan, and typically include:

- the recapitalization plan for fast-growing Subsidiaries;
- the dividends distribution plan for the Holding Company and for each subsidiary.

More precisely, the Top Management poses its commitment on the ability to generate a certain amount of dividends to shareholders, who the Board is representative of. Therefore, the actual dividends policy results to be put together following five steps:

- Board defines the risk appetite and the overall return on capital target;
- Top Management allocates return on capital targets to the various BUs and translates it into a target dividends policy;
- Top Management, with the support of the various business structures, plans a way in order to achive such targets;
- Top Management projects the full balance sheet over the plan time horizon with the support of business structures and of the Risk Management, who verifies that risk appetite tolerances are not breached;
- when a strategy is found such that return-on-capital targets are achieved while being in line with risk appetite, the plan gets approved by the Board.

The strategy might involve a mix of:

- management actions, e.g. lowering the financial guarantees embeedded in new (and, where possibile, also in-force) business, changing the management of unrealized capital gains/ losses, etc.;
- risk mitigating actions, e.g. changing the reinsurance structures, changing the strategic asset allocation, changing the asset-liability duration mismatch;

- capital actions, e.g. proposing a recapitalization of the company or a dividends cut.

4.3.2 Examples of dividends policy

Capital management actions depend on the risk appetite and on the target remuneration the Top Management is required to observe / aims to achieve.

For example, a Group dividends policy may be composed of the following six principles:

- Group solvency position after dividend distribution is in line with Risk Appetite and sufficient to withstand stress scenarios defined by Risk Management;
- Holding Company Solvency II Ratio (also referred to as S-II Ratio) after dividend distribution is kept higher than a certain threshold (risk tolerance, e.g. 160%);
- Holding Company's dividends is kept in the range of 60% - 80% of Group net profits (e.g. 20% of the profit should be reinvested in the company);
- distributed dividends are capped at the firm's total statutory distributable reserves (i.e. distributable reserves such as revaluation reserves and carried-over profits);
- subsidiaries' S-II Ratio after dividend distribution is higher than 150%;
- solvency position is sufficient (i.e. higher than a risk-capacity threshold, e.g. 120%) after stress in the case of extraordinary dividend distribution.

Another example of dividends policy is the one published by Allianz in their 2015 final report [1], also discussed by Morgan Stanley and Oliver Wyman in [38].

The case of Allianz is interesting as the Group is one of the primary insurers that have been designated as Global Systemically Important Insurers (or G-SIIs); as such, an additional buffer (over the minimum SCR ratio of 100%) is likely to be required, the so called Higher Loss Absorbency (HLA) requirements which at the time of writing is likely to be equivalent to an additional 25ppts on the Solvency II ratio (i.e. roughly equivalent to a Standard & Poor's style 'A' requirement versus the base 'BBB' calibration of Solvency II). However, to comfortably run the business and absorb the inherent volatility in the business (which will become clearer under Solvency II), Allianz will choose to hold additional buffers over and above this minimum level of (approximately) 125%; hence the Group dividends policy is likely to only apply as long as the Group's economic solvency ratio is sustainably in excess of 160%. If the Group Solvency ratio is higher than 160%, then Allianz's dividend policy is to pay 50% of net income as a dividend, use another 20-30% of net income for M&A activities and keep the rest for internal growth. Note that management has defined a stress test as a scenario leading to a reasonable "hit" to solvency, i.e. a combination of equity markets falling, credit spreads widening and yields falling leading to around 30ppts decrease in the Solvency II ratio. This probably means that Allianz is likely to conservatively maintain a "double buffer" over and above its G-SII requirements; the extent of such double cover depends on the outcome of scenarios stress testing (e.g. available capital should be such that also in a, say, 1in10 stress scenario the solvency position is higher than 125%).

In general, the case of Allianz shows that the ability of firms to payout dividends is influenced at least by three elements:

1. the ability of the firm to generate profits - *profitability view*;
2. the risk profile of the firms underlying such profit generation - *risk view*;
3. the capital management strategy and the risk appetite of shareholders, which influences the level of required economic capital - *capital view*.

Hence, the Risk-adjusted strategic framework introduced in section 2.2 is best place to set up a dividends' optimization strategy, tailored to the specific features of the firm.

4.3.3 Application to our case-study

We have extended the EC-model defined in the section 4.2 to consider a multi-year time-horizon and a simple capital management strategy.

Keeping in mind that the focus of this work is not on modelling accuracy, we used the following assumptions:

	Base scenario			Scenario D			Scenario G			Scenario J		
Excess Capital generation	t1	t2	t3	t1	t2	t3	t1	t2	t3	t1	t2	t3
Opening REC	26	26	24	25	32	26	20	24	22	20	25	22
Opening Excess Capital	**49**	**49**	**51**	**50**	**43**	**49**	**55**	**51**	**53**	**55**	**50**	**53**
Sustainable surplus generated	7	9	7		9	7	2	5	6	2	7	6
Capital to be raised	3	3	3	3	6	3	3	6	4	3	6	5
Max (dividends)	*53*	*55*	*55*	*47*	*46*	*52*	*54*	*50*	*55*	*53*	*50*	*54*
Dividends	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
Closing Excess Capital	**49**	**51**	**51**	**43**	**49**	**49**	**51**	**53**	**53**	**50**	**53**	**53**

Table 4.7: Results of capital projections and dividends policy (M)

- the calibration of correlations and marginal distribution of the risk factors is assumed unchanged over the time horizon;
- the change in available capital from a year to the following one is allocated proportionally to each asset class;
- being a pretty risk-adverse Group, the risk appetite is set to be equal to a prudent 284% over the whole projection period, so that

$$\frac{REC_t + Excess\ capital}{REC} \geqq 284\% \ \forall t \in [1, ..., T]$$

- the target dividends level is set to be equal to 10m every year.

Results are summarized in Table 4.7 and lead to two final comments.

The first relates to the fact that, also thanks to diversification benefits and to the management initiatives set up in the previous section, the dividends flow appears to be pretty stable over time; however, the company should carefully consider the fact that every year it is requesting investors to raise some capital (between 3 and 6 m): albeit this is a relatively small amount, the Board should probably consider either to relax its risk appetite (284% is a very high threshold to maintain!) or to foster returns.

The second comment relates to the key profitability metric to be used: indeed, the closest metric to dividends generation appears to be the *Sustainable Free Surplus* generated (see definition in section 2.6), i.e. a new measure which is starting to become best practice in the industry. For instance, in their 3Q investor day 2015, the Top Management of Credit Suisse stated that their "strategy is to focus on free capital, both to fund growth and to generate return for shareholders", as other "profit based metrics such as pre-tax income and return on equity ignore increases in capital usage, i.e. can have high net income but be capital consumptive". They are rather going to be increasingly using Sustainable Free Surplus Generated as it is able to

- assess "the overall performance of Credit Suisse Group";
- "guide the capital allocation";
- provide a proxy "as a target for dividends";
- act "as a metric to measure divisional performance".

The four reasons above can duely be considered a good way to ensure that a metric is actually embedded in the firm's decision making process, and therefore is "meaningful" in the sense used by de Finetti [17].

4.4 Using EC to link product pricing with ORSA

Having described how an EC model can be used in order to define business initiatives and capital actions, this section focuses on how a risk-adjusted performance framework can influence product pricing. This is consistent with EIOPA's Guideline #13 of [49], which states that firms "should take into account the results of ORSA and the insights gained during the ORSA process in product development and pricing".

In order to do so, in the next subsection we:

- introduce the drivers which are fostering a revolution in product pricing;
- highlight the key features of a new pricing approach based on risk-adjusted performance targets;
- discuss a few remarks on such evolution and related perspectives.

4.4.1 Three elements which are fostering a pricing revolution

At least three elements are pushing the industry towards a complete review of the way insurance products are priced:

- the regulatory push related to ORSA, involving the requirement to consider risk in every strategic and management choice;

- the will to capitalize the important investments placed on risk management framework, risk modelling methodology and IT infrastucture;
- the business need to evolve the way insurers think of pricing towards a more market (rather than technical) centered approach.

Regarding the first element, apart from the already mentioned EIOPA guidelines, a number of national Regulators explicitly require firms to "assess their own strategy related to product development and structuring in light of ORSA findings". They should also make an assessment, for each newly new product, of the following four components, to be documented in a technical report (see, for instance, the recently approved Italian law-suit related to Solvency II [45]):

- insurable risks covered by the product;
- hypotheses underlying the pricing process;
- expected profitability;
- expected premium equilibrium.

Hence, while technical sustainability should still be checked by actuaries using the well-established traditional actuarial pricing methodologies (see, for instance [52]), the innovation which actuarial research has recently begun to investigate is to move from pricing models which do not represent the specific risk profile of the product towards a *new pricing approach which is based on the actual risk profile of the product in the context of the pre-existing product portfolio.*

In order to achieve such target, three principles should be introduced in the way products are priced:

1. coherence with the Risk Appetite, in order to appropriately considering risk given investors' preferences;
2. coherence with the overall profitability target, promised to shareholders and formalized in the dividends policy;
3. coherence with the Economic Capital structure of the firms, thus considering the various risks taking diversification benefits into account.

In the next subsection, we present an approach which translates such principles into an approach which ensures that pricing is consistent with the target remuneration and risk appetite.

4.4.2 A new RAP-target approach for product pricing

In this sub-section we suggest a way to merge the RAP-target and the technical pricing approaches.

The high-level pricing process consist of 4 main steps:

1. data and risk mapping: collect information about insurable risks covered by the contract and identify the key risk drivers (e.g. age of the insured, city of residence etc., depending on their focus);

2. techincal pricing: calibrate the pricing formula as a function of the identified key risk drivers and calculate technical pricing (including foreseeable covered claims and expenses);

3. profit testing: make valuation assumptions (interest rate scenario, CAT scenario, etc.) and measure standalone product profitability assuming technical pricing (so called "profit testing");

4. commercial distribution: agree with the distribution structures (underwriters, agents, commercial banks) the pricing flexibility range (e.g. in terms of discounts) depeding on technical price and profit test results.

When we move to a RAP-target approach, the main idea is that the product features, risk profile and pricing should be such that the *allocated target RAPM* should be hit. Hence, the process becomes the following:

1. allocation of profit and REC, i.e. allocation of profitability and required economic capital to each business unit and product;

2. definition of a RAP-target, for each new product, consistent with the overarching return of capital targets and risk appetite set by the Board;

3. assessment of the RAP-targeting premium, i.e. calculation of the minimum price which ensures that the product hits the RAPM-target and assessment of technical sustainability (considering expected claims and expenses);

4. definition of an optimal price, considering commercial factors such as competitors pricing, brand recognition, elasticity of demand and supply etc.

Step 1 (Allocating profits to ensure accountability) While we already discussed key features, challenges and solutions related to allocation of required economic capital in Chapter 2, in this paragraph we focus on allocation of profitability, as a lever of the Top Management to ensure that the right incentives are given to business structures.

Regulators, rating agencies and investment markets have recently put increasing attention on risk controls embedded within the financial institutions they monitor, rate and value. At the same time, risk management can now rely on increased computational capabilities and more complex models. As noted by Shang & Chen in [45], "those factors, however, did not prevent financial institutions from going bankrupt or needing government bailout", notwithstanding defaulted firms stating "they had good risk management policies and implementation" and not trivial amounts of resources spent on risk management.

It therefore appears to be crucial to make sure that the risk management process does not resolve to be a compliance exercise, but rather proves to be embedded in the daily management of the business. The stated objective of a RAPM framework is to enable firms to maximise shareholder value given their risk appetite and taking the opportunity cost of capital into consideration. Identifying the appropriate set of incentives is the best way to force senior management to think in terms of risk-return. In particular, the performance of a business should be translated into specific Key Performance Indicators (KPIs), which the managers' performance scorecards should be related to.

For instance, economic measures such as RAROC and EVA (discussed in chapter 2) have increasingly been adopted by banks to evaluate three of the main functions usually responsible for different risks:

- Investment function: responsible for actively managing an asset portfolio, departing from the base (passive) strategy (so called Strategic Asset Allocation – SAA[7]) in order to achieve higher returns than ex-

[7]The Strategic Asset Allocation (SAA) is used to determine a long-term policy portfolio reflecting the desired systematic risk exposure. Tactical Asset Allocation (TAA), on

pected;

- ALM function: responsible for minimizing mismatch between assets and liabilities;

- Business Management function: responsible for new business growth and gains from non-financial risks.

In Life insurance companies, where longer periods than in banks are required before gaining profits, MCEV is a good candidate for measuring economic value and economic profit. MCEV can be decomposed into value generated by the three functions listed above as follows (and illustrated in Figure 4.6):

- higher return than assumed using the SAA following any active asset management strategies are due to the Investment function. For example, if interest rates are expected to go up, the investment department may decide to increase the duration of assets compared to the duration of liabilities;

- the difference between the SAA return and return gained on the replicating portfolio of liabilities is earned due to the mismatch between assets and liabilities, and should therefore be attributed to the ALM function;

- the difference in values of the replicating portfolio and actual liabilities (if it occurs) is due to any other non-financial risks and should be attributed to the business management function.

Remark 4.7 on economic value added by single functions Note that any extra return should be adjusted for the additional cost of capital required. For example, an increase in the A-L duration mismatch leads to higher expected profits, but also to higher Required Economic Capital, as discussed in the simulation in section 4.2.

Using this approach, it is possible to calculate the Economic Value Added by each function, for example as shown in Table 4.8, following the generic

the other hand, specifies the allowable deviation from SAA to take advantage of short-term market opportunities. The investment department can therefore manage an asset portfolio actively as long as the resulting portfolio does not stray outside the allowable range specified by the TAA.

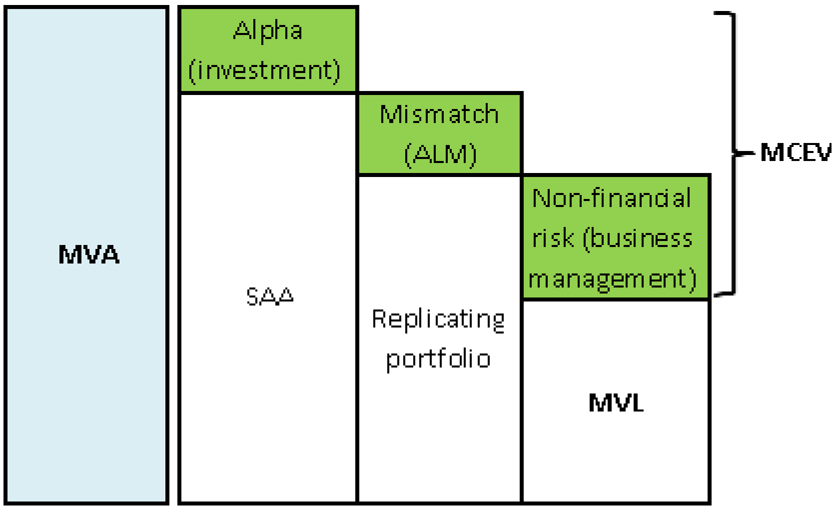

Figure 4.6: MCEV-based allocation of profits

Function	Allocated profit	Explanation
Investment	$EVA_{Inv} = \begin{cases} r_P & - \\ r_{SAA} & - \\ CoC \cdot REC_{Inv} \end{cases}$	$\begin{cases} Extra\ return\ over\ SAA & - \\ delta\ in\ cost\ of\ capital \end{cases}$
ALM	$EVA_{ALM} = \begin{cases} r_{SAA} & - \\ r_{L-R.ptf} \end{cases}$	$\begin{cases} Return\ from\ SAA\ mismatch & - \\ Replicating\ ptf\ of\ liabilities \end{cases}$
Business Mgmt	$EVA_{BM} = \begin{cases} NBV & + \\ E\left[r_{L-R.ptf}\right] & + \\ \pi & - \\ CoC \cdot REC_{BM} \end{cases}$	$\begin{cases} NewBusinessValue & + \\ Return\ on\ replicating\ ptf & + \\ Non-financial\ profit & - \\ Cost\ of\ capital \end{cases}$

Table 4.8: Example of allocation of profit among functions

approach of

$$EVA = earnings - opportunity\ cost \cdot allocated\ capital$$

Further details on the measures defined above can be found in [45].

Step 2. (Definition of a product-specific RAP-target) Say that the chosen RAPM is *Return on Risk Adjusted Capital* (RoRAC) and that a company sets $RoRAC_t^*$ as the target return to be achieved for holding an economic capital consistent with the Board-defined Risk Appetite.

Then, the Top Management will have to "cascade" such target down to each Business Unit until a product granularity level. Therefore, a RoRAC target will be set for a given product i which is launched at time t as the following:

$$RoRAC^*_{i;t} = \frac{r^*_{i;t,t+1}\left(RoRAC^*_t\right)}{REC^i_t} \tag{4.1}$$

where

- $r^*_{i;t,t+1}$ is the return needed from product i in the next year in order to achieve the firm's target $RoRAC^*_t$ given information at time t;
- REC^i_t is the amount of economic capital allocated to product i that the firm is required to hold at time t in order to be consistent with the risk appetite of the firm.

Remark 4.8 Two important challenges arise in order to allocate capital at product level:

- allocating REC at product level might prove to be a technical challenge for firms which calculate it using a standard formula approach, as the highest level of granularity in the standard formula SCR calculation is by line of business;
- for portfolios selling multiple products in multiple geographies and markets, cascading a RoRAC target for a new product is likely to be a highly discretionary exercise, given that volumes are such that a single new product is likely not to materially impact the risk-return profile at firm's level (i.e. the $RoRAC_t^*$).

Regarding the first challenge, standard formula companies are developing ways to allocate capital at product level using LoB's capital absorption. In the non-life case, for example, a solution companies are implementing involves three steps:

- identify the LoBs which the product is a mix of;
- calculate capital absorptions at LoB level (e.g. by using an Euler allocation method);
- allocated capital to the product as a linear combination of the LoBs.

Regarding the second challenge, the weight of the product-specific risk-adjusted profitability target ($RoRAC_{i;t}^*$) will clearly need to be weighted by the product budget over next year; if the impact on the overall firm's target ($RoRAC_t^*$) is still negligible, then the Top Management will need to take a view on how to cascade the target by product. At the end, target setting is more a strategic activity (albeit informed by quantitative assessments) rather than a pure technical exercise.

Step 3. (Assessment of the RAP-targeting premium) Following step 2, a target RoRAC has been defined for any product i as $RoRAC_{i;t}^*$. The next step involves finding the premium π_{RAP}^* (which we will call as the *RAP-targeting premium*) that allows to achieve the target product-RoRAC and is also coherent with the profile of the insurable risk and of the firms cost structure. In other words, it should be checked that the RAP-targeting premium enables premium equilibrium in a more traditional actuarial sense.

Consistently with the pricing model 3.6 introduced in chapter 3, we therefore have:

$$\pi^*_{RAP} \therefore \frac{\pi^*_{RAP}\left(1+r_{0,1}\right)-E\left[X\left(1+e\%\right)\right]}{REC^i_t} \geqq RoRAC^*_{i;t}$$

Step 4. (Definition of an optimal price) Once we have defined a minimum premium which allows hitting the risk-adjusted profitability targets and is sustainable from an actuarial perspective, the goal of the underwriting and distribution processes is to find an *optimal price*, i.e. a price (at least equal to the RAP-targeting premium) which adds the most economic value.

In order to achieve this aim, the pricing policy should:

- be sensitive to demand elasticiy (e.g. increasing prices for products with a low demand elasticity creates value because the loss of volumes is more than compensated by the increased price);
- carefully consider the availability of substitutes and the competitive behaviour (e.g. using a game-theoretic approach, anticipating how competitors will react to any change in prices);
- allow for some discretion at the point of sale, in order to extract the most consumer value;
- closely monitor the use of delegated price authorities and promotions;
- react quickly to pricing cycles and changing financial conditions.

Further discussions on the factors above to be considered while setting up an optimal pricing policy are provided, for example, by Wilson in [52].

4.4.3 Remarks and perspectives of this "revolution"

It has been argued that adopting a risk-based approach in pricing is not really a revolution, given that absorbed risk-adjusted capital is often allowed for already while doing a profit testing. However, most of the times such tests are based on product standalone capital, i.e. as if that product was the only product which the firm is selling. The key innovation is that the assessment needs to be based on *how much capital the product absorbes given the wider* *company's portfolio.* In other words, from a firm's strategic perspective the aim is to investigate the effect of the new product on the firms risk-return profile.

This provides a double sided effect:

- on the positive side, it gives information to the company as to what sort of business they would have a comparative advantage in selling, compared to competitors;
- on the more arguable side, this pricing approach might lead, for a single insurable risk, to as many prices as selling insurers: for a given insurable risk, premium will not be unique anymore.

For instance, a non-life retail product providing a CAT cover might be more attractive to a company "A" which appears to be too concentrated on, say, motor business and on market risks (so that selling CAT guarantess might provide a good hedging opportunity) than to a company "B" which is already overly exposed to the same CAT risks. This will allow company "A" to provide the CAT cover at a lower price than company "B", so that the CAT cover for company "B" becomes either "unsellable" (as the price is much higher than that offered by for company "A") or un-sustainable (as the price is too loow considering its risk-return profile).

Believers in the free market will find this to actually be a fully positive impact, as it creates favourable conditions to insurers who:

- are provided with methodologies, processes and infrastructure able to correctly implement a RAP-target product pricing approach;
- have a genuine competitive advantage in selling certain guarantees compared to peers.

To conclude, such evolution in product pricing also has an impact on the governance side, where firms are setting up and strenghtening products committees. Such committees are evolving, from being an (albeit important) moment where a new product is discussed from a marketing and from an actuarial perspective, to become a central enabler of business strategy steering and execution, in which risk and capital management play a key role in order to define products which are profitable and consistent with the firm's capital management plan and risk appetite framework.

This concludes the discussion on how a risk-adjusted framework can be used in order to define a value-creating strategy through re-defining the concepts of business planning, capital management and product pricing.

Chapter 5

Outlook of insurers' operating model, investors' views and actuaries' role

By designing Solvency II as the new regime for the insurance industry, the European regulator played the role of a game changer, forcing firms to develop new ways to assess their own business and actively manage risks and capital.

The next page of this journey towards a new way in managing the performance of insurance firms by using economic capital materializes into three factors:

- the way insurance firms operate: insurers are looking for optimal ways to make full use of the huge modelling and IT investments made in the past few years; in order to do this, business processes should be re-designed, so that risk is properly taken into account and decision making is based on economic capital assessments;

- the way insurance firms are valued: the insurance industry is a very different (and complex) business compared to anyone else; as such, it cannot be valued like other industries, but specific measures are required in order to understand the peculiarity of this business; the newly defined economic capital based metrics (the RAPMs) provide investors with new information which can be used to make more informed decision when trading insurers;

- the essence of actuaries and of their role: in such a chaning landscape, actuaries evolve from being pure technical specialists (often liability-oriented) to becoming professionals equipped with the right skills, knowledge and mindset in order to steer, influence or control the strategy of a firm.

The next sections expand the three factors introduced above, and provide the perspective ahead of the insurance industry following from the scientific itinerary followed in this thesis, on the ways economic capital can be used to manage the insurance business by defining a new risk-based corporate finance.

5.1 A new EC-based operating model for insurers

This thesis chapter provided an *iter* across:

- technical remarks on how to calculate, allocate and use Economic Capital in order to define a Risk-Adjusted Performance measurement system for the company (chapter 2);
- an application showing how setting up a RAPM-based system makes the sustainable profit of a company much more volatile (chapter 3);
- a simulation model showing how an Economic Capital can be used in order to design optimal management initiatives and how these differ from a traditional ROE-based approach (chapter 4).

In order to turn such methodological advances into practice firms need to set up processes and organizational structures which enable to effectively steer the business considering risks and optimally managing economic capital. In other words, a new EC-based operating model for insurers is needed.

The new operating model is based on the following building blocks:

1. Strategic steering processes: these include setting up the return on capital targets and the risk appetite of shareholders; these are typically driven directly by the Board of Directors, with support from Top Management and Risk Management function;
2. Budgeting and Capital management plan: Top Management allocates capital to the various business units, legal entities (if it is a Group)

and business processes (e.g. investments, underwriting, etc.); such capital allocation exerise is included in a draft capital management plan, which also includes the projected use of capital (including any dividends to be distributed/ capital injections to be requested); the capital management plan cannot be closed if the ORSA exercise (see process below) has not been finalized;

3. Cascading of targets and risk appetite: in this phase, Top Management sets profitability targets and risk limits for each business unit and business process, consistently with targets posed by the Board;

4. ALM and Strategic Asset Allocation: this includes how assets and liabilities are managed in a unique value framework; further discussions on Strategic Asset Allocation, in particular, can be found in the previous chapter;

5. Product Planning and Reinsurance: new business should be planned considering commercial elements (e.g. costumer needs, competitive landscape) as well as the risk-return profile of the firm (ALM and ORSA findings); similarly, the policy of a firm towards reinsurance can be informed by the desire to save capital or to explore opportunities in new peculiar lines of business (e.g. catastrophe covers);

6. Own Risk and Solvency Assessment (ORSA): this also includes the forward looking assessment of own risks (both capital and pillar 2 risks), projections of solvency positions (and thus definition of dividends) and scenario and reverse stress testing (and contingency planning), in order to assess the sustainability, profitability and dividends policy achieved by the firm's capital management plan, strategic asset allocation and product plan, considering the tarket return on capital and risk appetite;

7. Sign-off of Strategic Plan and ORSA report: the Board should sign off the Strategic plan and the ORSA report (including evidence of the capital management plan, of the strategic asset allocation, of the product plan and of the reinsurance policy); these two documents, should be disclosed, respectively, to the market and to the Regulator;

8. Regular business processes: once the plan has been signed off, it needs to be implemented; this is done by the various business units/ depart-

ments responsible for each business process, such as investments (often responsible for the Tactical Asset Allocation), underwriting (which, for instance launch the new products in the market and often price them, together with the actuarial function, taking economic capital into consideration), and reserving; note that each business process needs to be monitored in terms of performance target and risk limits (the so-called “first line of defence”);

9. Sign-off of Balance Sheet and QRTs[1]: the ex-post evidence of results achieved with the realization of the strategic plan needs to be regularly reported to the Top Management (so called “management information”) and to the Board and disclosed to the market and to the Regulator; the huge amount of information produced should therefore inform the firm’s decision making process and external assessment (of market, investors, rating agencies and supervisors) as well as provide a basis for the next planning exercise.

While the Regulator doesn’t prescribe any specific operating model firms should refer to, each company is free to design the model which best suit its history and vision towards the future. Above we provided an example of how an insurance operating model might work in practice, so the numeration also reflect the cronological order a firm might choose to roll out such processes.

3 remarks on ORSA To date, the general industry view of ORSA has been that it is a regulatory requirement introduced by Solvency II. In reality, ORSA is set to mark a step change in how risk and economic capital management is embedded in an insurer’s planning processes and day-to-day decision making. To enable such step change three remarks are to be considered.

> **Remark 5.1 on Stress testing**
> Properly including stress testing in any ORSA exercise means linking the stresses to the plan assumptions (scenario analysis) as well as identifying the “break scenarios” which would significantly impact the company (the so called critical scenarios already mentioned in 2.5.4); results of stress testing should also lead to the design of contingency plans, suited to the firm’s characteristics (i.e. think about what would you do if things went wrong?)

[1] Quantitative Reporting Template, required by Solvency II and providing detailed information about the company’s solvency position every quarter

Remark 5.2 on Connection with the Business as Usual (BaU)
The risk profile and the economic solvency position of the firm assessed in the ORSA process should play a central role in pretty much all the other strategic and business processes:

- the ORSA should coincide with the planning activity (and the Board sign off of strategic plan should come alongside with the sign off of the ORSA report), so that business direction and strategic decision making are defined in line with the insurer's overall risk appetite;
- the capital management plan should be adjusted considering the ORSA; for instance, the dividends policy is an outcome of the solvency ratio projection depending on the risk appetite of the firm; ORSA valuations should also help the Top Management to steer the company growth by balancing capital and returns, using the allocation of economic capital as a lever to optimize risk-return trade-off;
- assets and liabilities should be managed so that the level of risk is coherent with the firm's risk appetite whilst hitting profitability targets; a Strategic Asset Allocation probably is the best example of how this can be achieved, and should be assessed through ORSA projections;
- new business pricing should be adjusted for risk, considering economic capital loadings based the ORSA projections;
- ORSA valutation should take the accurate (and huge amount of) information provided by disclosures (e.g. the QRTs), but may not necessarily be based on them (e.g. it should reflect an "internal assessment" of non quantified risks, i.e. the so-called Solvency II Pillar 2 risks, such as Reputational, Strategic, Contagion and Compliance risks, which are not included in standard disclosures).

Remark 5.3 on Business sustainability
In order to make ORSA a truely comprehensive assessment of a firm, it should not only focus on risk and solvency position, but also on its profitability profile. This means that the assessment should include a view on how profitable the firm is (rather than only how risky or how solvent it is), and where this profitability comes from.
A first step towards this direction has been made by EIOPA in requesting internal model firms to perform Profit and Loss Attribution, as a standard to ensure that their internal model covers all material risk factors which originate profit and losses. However, the insurance industry is still far from what the banking industry named the "Business Model Analysis" (BMA); this is a component of the Supervisory Review Evaluation Process (SREP), which supervisors are requested to perform on regulated entities. BMA means verifying how the business model of the bank is profitable and sustainable both in the short and medium-long time period (see original documentation from the ECB [23] for further details). Taking risk-adjusted profitability as a key metric to be assessed, ORSA may therefore be used not only to assess but also to optimize return on capital targets, as discussed in chapter 4.

Following these three remarks would mean enabling a firm to extract value from ORSA beyond mere regulatory compliance, so that it supports a clear understanding of the risk and return trade-offs of various strategic decisions. Who leads the ORSA (often the Risk Management function), will therefore evolve into a business sparring partner that contributes towards a continuous and tailored risk assessment, through systems able to perform projections and what-if analyses, in order to support the other business functions, not to limit them.

5.2 A summary template to value the firm

As explained throughout this thesis, Economic Capital provides the Top Management with a wide variety of indicators which can be used in order to inform decision making process. However, regulations are in place in order to push companies to disclose a huge amount of data to the market, which investors can use in order to assess the company. Some of these indicators have been defined and used in this thesis.

Figure 5.1 shows a mapping of key indicators structured by Profitability

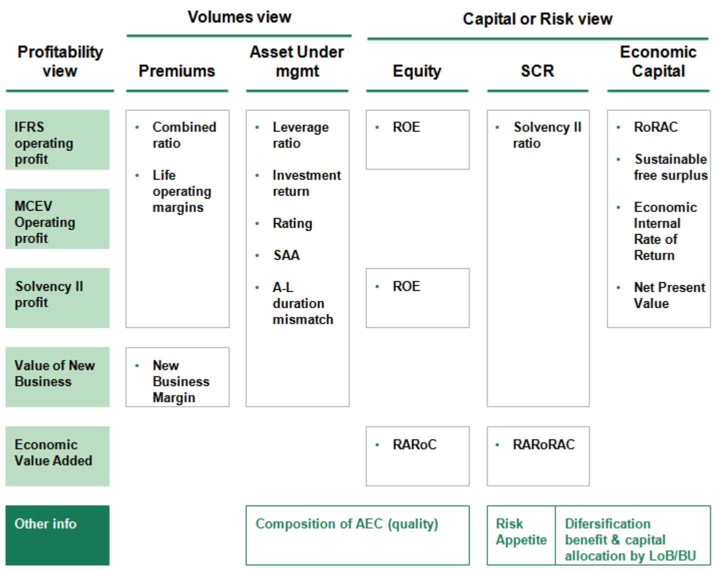

Figure 5.1: Mapping of performance indicators for insurers by profitability, volumes and capital/risk view

vs. Volumes (i.e. Growth) and Capital/Risk views. For instance, a way to capture Economic Value Added (profitability view) and Equity (capital view) leads to the definition of a RARoC performance metric. For a definition of terms not defined earlier, such as New Business Margin and Leverage Ratio, see, for instance, [38]. The mapping is complemented by three key ingredients of the status and strategy of a firm, i.e. the quality of its available economic capital, the risk appetite which the required economic capital is calibrated on and the capital allocation across BUs.

In an economic capital based world, it is important that firms start informing their business decisions using summary templates similar to the one above, related to different Business Units or to different strategic option (e.g. if dealing with a decision of either (a) implementing initiatives to evolve a BU which is currently loss-making or (b) putting it into run-off, it would be interesting to see what the impact would be in each case in terms of projected Solvency II ratio, projected profits, and Net Present Value).

Similarly, market players interested in investing in the insurance industry might want to fully understand the fundamentals of the business, rather than rely on more traditional cross-industry multiples, such as price to earnings. Wilson [52] demonstrates that price to earnings, for instance, is actually flawed for the insurance sector, as it ignores the capital required to generate the earnings (i.e. more specifically, "whether the marginal capital invested for growth creates or destroyes value by generating earnings in excess of the risk-adjusted cost of capital"); the P/E measure should rather be replaced by a more market-consistent M/B ratio[2].

In summary, Economic Capital and RAPMs provide an important step forward towards a more coherent, forward-looking and comprehensive assessment of insurance firms which investors should leverage in order to make more informed investment choices when dealing with the insurance sector.

5.3 The rise of strategic actuaries

As described throughout this thesis, the perfomance of an insurance company can be managed to become more stable and profitable using economic capital. In such a new risk-based corporate finance, three ingredients are necessary:

- sound quantitative bases, in order to be able to master the methodology behind the calculation and allocation of economic capital and derived RAPMs;
- deep expertise in the dynamics of the insurance business, as the insurers operate in a very peculiar and complex sector;
- ability to drive the two ingredients above with a strategic attitute.

Looking at actuaries as potential professionals provided with the ingredients above, the UK's Faculty and Institute of Actuaries already defines actuaries as "problem solvers and strategic thinkers with a deep understanding of the financial systems and highly valued mathematical skills and expertise, which they use in order to measure the probability and risk of future events". It seems therefore that a risk-based corporate finance requires actuaries to further evolve from the traditional focus onf insurance liabilities.

Indeed, looking at actuarial types, it has been argued that four types of actuaries existed in the history of actuarial sciences; the passage of actuaries

[2] It is argued that the price the market is willing to pay for a company is equal to its current book equity plus the growing perpetuity of excess returns generated by reinvesting returns net of dividends to grow the business ($\frac{V}{E_0} = 1 + \frac{RoE - CoC \cdot E_0}{CoC \cdot E_0 - g_E}$); using the P/E ratio, however, the theoretical price of a share is equal to the present value of its growing dividends flow distributed to shareholders ($\frac{P}{Ea} = \frac{d}{CoC \cdot E_0 - g_E}$). See [52] for further details on this topic.

from a kind to the next one provided a change both on a market level and on skillset level:

- *First kind:* The first generation of actuaries emerged in the 17th century, were focused on life insurance valuations and tended to use deterministic methods;
- *Second kind:* Developed in the beginning of 20th century, these are casualty actuaries who used probabilistic approaches to deal with workers compensation, automobile insurance, property insurance and similar risks;
- *Third kind:* Actuaries of the third kind typically had an investment focus, able to apply stochastic processes, contingent claims and derivatives to assets and liabilities; these developed in the 1980s as financial risk became more important and tools to manage financial risk were created;
- *Fourth kind:* This kind of actuaries developed deep expertise in Enterprise Risk Management, and were the first structurally able to work outside the financial industry; the development of these led to the creation of professional qualification such as CERA[3].

Buhlmann first offered the classification of the first three types of actuaries in [7], while the fourth was suggested by Embrechts in 2005 and specified by Archy in [2].

We argue that the flourishing of Economic Capital as a concept to manage insurers' performance may lead to the proliferation of a a further kind of actuaries, i.e. professionals who expand their quantitative and technical background to a wider risk-based corporate finance (including the use of new techniques, e.g. Big Data and parallel computing) and use their skills in order to enhance the performance of the company and thus set up the strategy to be followed: in two words, *strategic actuaries.*

In other words, the recent developments posed by the regulators (on one side) as well as the huge challeges faced by public welfare systems (on the other) are leading to the need of professionals who may revert towards the core business of actuaries, i.e. insurance and "uncertainty management"; however this will be done with two distinctive features:

[3] Chartered Enterprise Risk Actuary

- the focus on strategy, profitability and sustainability of the business;
- the attention towards public policy and regulatory framework.

While the former feature has extensively been discussed in this thesis, the latter finds the following two good examples today:

- in the UK's "Government Actuary's Department", i.e. an institution "whose mission is to support effective decision-making and robust reporting within government as the first choice provider of actuarial and specialist analysis, advice and assurance". Scope of actuarial contribution on public policy matters can range from pensions policy and regulation to statistical and actuarial analysis (e.g. on longevity of the population), from investment and strategic risk management to CAT risk management and healthcare financing;
- in the recent experience of the Italian National Insurance Institute for work-related risks (INAIL), which recently completed a project aimed at enhancing the data quality and IT architecture of nation-wide casualty data, which are now open for public use [29]; this was pushed by the Italian government, whose ministers of Economics and Finance and Job and Welfare requested INAIL to verify the "economic, financial and actuarial sustainability" [31] of the Institute, considered to be of public interest.

It follows that actuaries have the chance to play an important strategic role also to inform strategic decisions in public policy. After all, the ethimology itself of the word strategy (from the ancient greek στρατηγὸς, "general of the army") refers to the science of effectively coordinating the movements of an army, mastered by generals in ancient Greece and roman empire times; more broadly, Aristotle referred to *rhetorical strategy* as the research for the success in a competitive context.

The strategic actuary, therefore, should focus on developing advanced risk-based corporate finance models and use them to identify actions and initiatives which would maximise value creation, considering the standpoint of shareholders (profitability), policyholders (solvency, or safety) and the market in general (sustainability).

Hence, coming back to the insurance industry, the changed regulatory landscape, including Solvency II, as well as the new wave of economic capital focused business models, give actuaries the opportunity to further evolve from more traditional activities, such as liability valuation (even in the most recent forms, such as the setup of the actuarial function), towards being key resources equipped with the right quantitative and technical skills to play a key (top management?) role in business steering in order to find the right balance among growth, stability and profitability, in a new Risk-Adjusted Performance system.

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